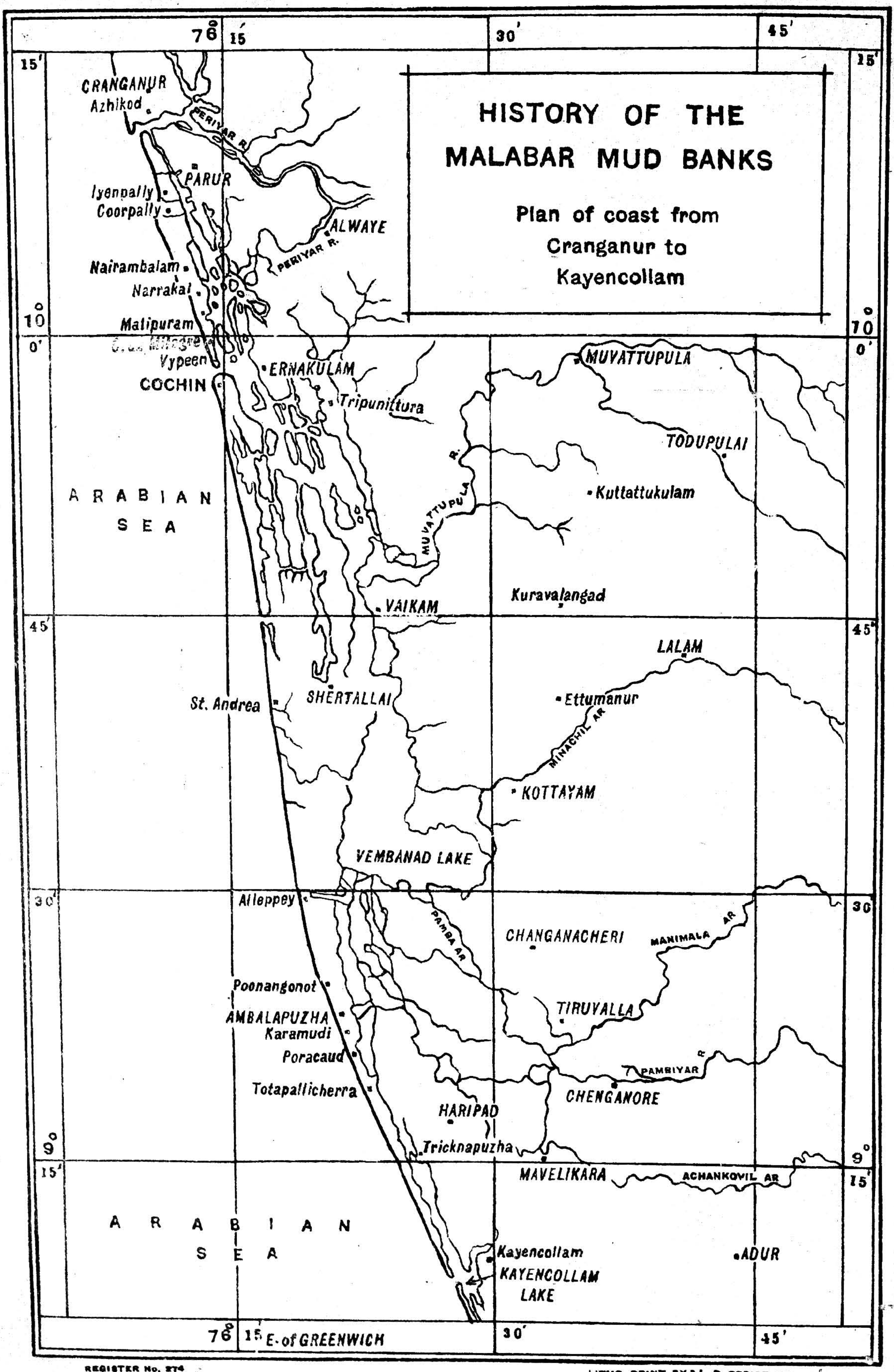

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COCHIN HARBOUR DEVELOPMENT

HISTORY OF MUDBANKS

VOLUME I

COMPILED FROM THE AVAILABLE RECORDS

WITH AN INTRODUCTION

BY

MR. R. C. BRISTOW, C. I. E., M. Inst. C. E., M. I. Mech. E.,

Administrative Officer and Harbour Engineer-in-Chief,

Cochin Harbour.

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TABLE OF CONTENTS

Chapter		Pages
I.	Introduction by the Administrative Officer and Harbour Engineer-in-Chief, Port of Cochin	1— 6
II.	Extracts from the Malabar Gazetteer	7— 12
III.	The reports of John Castor, Esq., Master Attendant at Cochin dating from 1861	13— 64
IV.	Extracts from the Madras Journal of Literature and Science, 1860	65— 77
V.	Records of the Geological Survey of India ... ... Dr. King's work of 1881.	79—100
VI.	Records of the Geological Survey of India ... ... Mr. R. D. Oldham's note of 1881.	101—105
VII.	Records of the Geological Survey of India ... ... Mr. R. D. Oldham's note of the earthquake of 31st December 1881.	107—118
VIII.	Records of the Geological Survey of India ... ... Mr. Philip Lake's report of 1888—1889.	119—131
IX.	Extract from the Travancore State Manual, Volume I. Published 1906	133—140
X.	Extract from the Cochin State Records, 1888 onwards ...	141—146
XI.	The personal recollections of G. H. Davey, Esq., 1880—1937	147—157
XII.	Various reports and correspondence with the Geological Survey of India in reference to the Earthquake of January 1934	159—165
XIII.	Some opinions by Civil Engineers...	167—174

CHAPTER I

INTRODUCTION BY

R. C. BRISTOW, C. I. E., M. Inst. C. E., M. I. Mech. E.

COCHIN HARBOUR DEVELOPMENT

HISTORY OF MUDBANKS

CHAPTER I

There are four well-known mud banks off the S. W. coast of India, one at Alleppey, one at Cochin, and two at or near Calicut. Reckoning by English miles along the coastline from Cape Comorin westward and northward, the distances are, approximately, Alleppey 135 miles, Cochin 170 miles, Calicut 260 miles. (The distance measured due north from Cape Comorin to the latitude of Cochin is roughly 130 miles, not 100 miles as stated in previous publications). Three of these mud banks are either at or near the mouths of rivers or lagoons; the fourth, at Alleppey, is separated from the great Vembanad Lake by a narrow strip of sandy foreshore. It is not certain, but there may be other banks, not so well-known. All these mud banks have the special property of giving complete quiescence to the waters above, even in the roughest monsoon weather.

2. The sea-bed off this part of the coast is also mud, stretching probably as far as the 20 fathom line, roughly 17 miles distant; but this mud does not give the same quiescence to the water. The coastal currents are supposed to run south for 8 months in the year, to be more or less stationary for a month, and to run north for the remainder. The Meteorological Atlas shows varying speeds, roughly in proportion with wind velocity. The greatest speed is stated to occur in July or August ("Ocean Passages for the World" p. 181). Observations tend to show that these features are variable. For example, there is practically complete agreement among sailors that the north to south drift has been much stronger since 1934 or 1935. The opposing force is the south-west swell set up by wind waves before, and at the beginning of the S. W. monsoons, and the long deep ground swell generated in the Arabian Sea which reaches Cochin about the middle of July. No doubt, taken over a long period of years, the records, if available, would show varying

preponderating influences, and possibly, a fairly regular cycle of them, such as may be noted on the sand beach south of Cochin, which advances and recedes at intervals of about 20 years, the nett loss or gain being inappreciable during the last 100 years.

3. The old mud bank just north of Cochin known as the Narakkal or Malipuram bank is also susceptible to these fluctuations. In 1860 its centre was about 7 miles north of Cochin. In 1888 it was about 3¾ miles; in 1920, about 5 miles; in 1937 about 2½ miles. (These distances can be judged from its visible part above low-water, which forms a huge area without a ripple at its seaward edges, even in rough weather). The cause of this backward and forward travel is exceedingly obscure, for it cannot be said that there are marked conditions of wind and current, *every year*, to force it along one way or another. An exceptional storm in one year might start it, but exceptional storms do not come every year, whereas once the bank moves, it apparently continues to move until something sends it back again, and this something has not yet been discovered at Cochin. At Alleppey one theory is that the bank, after moving south for ten miles or so gradually disperses, when another bank bursts through the sea-bed at Alleppey, always about the same place, owing to the presence of an "underground river" connecting with the Vembanad Lake. While this theory sounds far-fetched to a civil engineer, there was very probably, at one time, an outlet from the Lake direct to the sea, (at or near Alleppey), which has since been covered by the sand of the beach.

4. In addition to the four mud banks, and the sea-bed, it is suspected that there are other mud areas, possibly newer formations, which have not yet consolidated sufficiently to anchor themselves, even temporarily, in any locality. And there may even be a littoral drift of mud from north to south along the 4 or 5 fathom contour line, not previously suspected at Cochin and possibly deriving from the mouth of the Periyar River, 15 miles to the north. There is nothing to show that a highly silted effluent now proceeds from this old river, but it is not beyond the bounds of reasonable speculation to conceive of a deposit of mud, formed over a long period, being pushed farther south whenever exceptional floods pour through the mouth and turn south, as they do

occasionally. The years 1924 and 1931 both gave such floods, and that of 1924 was almost unprecedented.

5. It is however, extraordinarily difficult, if not impossible, to sound over hundreds of square miles of sea-bed at enough points to discover if these newer formations exist, and how they are moving from year to year. Even if many vessels were available for the purpose, the mud bottom when churned up by storms, and for a long time afterwards, is so soft that an ordinary ship's lead sinks several feet into it before the surveyor is conscious of any resistance. Even with the special wide flat-bottomed lead used at Cochin, it needs a practised operator to find the top of the liquid mud, especially in rough weather. The author himself, after 34 years' experience of harbour service, has often failed to find bottom at 36 feet, where the regular surveyor has given a "least depth" of 30 feet in the Cochin approach channel after the monsoon. This liquidity of mud is most marked in the Cochin Channel, but it occurs to a less degree at sea.

6. Whatever their origin may be, there have been evidences of new mud areas at Cochin since 1934, not connected with any known habit of the foreshore. For example, during 1935—36 captains of vessels twice reported soundings of 24 feet to the *south* of the channel, when the next morning nothing less than 28 feet at L. W. could be found in the same place. Again, a very definite extension and rising of the mud flats occurred to the north-west and north of the harbour in 1934, the year of the great earthquake at Bihar (16th January); and finally, in July 1937, notwithstanding the vast discharge from the backwaters, (resulting from 40 inches of rainfall during the month), the outer channel was suddenly invaded by a mass of silt about 4 or 5 feet deep, which, if the coastline had been continuous would undoubtedly have piled itself up on the foreshore. It is highly remarkable that, for the first time in history, this piling-up actually occurred at Calicut 2 months later, where the north pier, usually in 2 fathoms of water at its outer end, suddenly appeared high and dry above a mudbank which disappeared a few weeks later. As will be seen from the records which follow, this phenomenon is periodically observed at Alleppey, the last occasion being in August 1928.

7. The above remarks are merely a brief introduction to the subject. No attempt has been made to summarize or reconcile the many views expressed in the past. On the whole, the main facts relating to the old mud banks are fairly well established, so far as they go, but the author reserves for a second volume, the material for which is being prepared, a more detailed and accurate account of the subject. Although the quantity of silting in July 1937 was enough to have put many ports out of action, Cochin remained open to vessels drawing practically 30 feet of water through the whole of the monsoon and after, and the "Lord Willingdon" swept the channel clear in a month's dredging, as usual.

8. In the chapters which follow are contained the record of actual observations and the views of seamen, laymen, scientists and experienced harbour engineers. Chapter XI, contributed by Mr. G. H. Davey, a present resident of Kottayam, Travancore, gives perhaps the most authentic information about the Alleppey mud bank, and is highly interesting as a personal record of long experience in South India. The author wishes to express his indebtedness to Mr. Davey, whose circumstantial recollections are most valuable. Although the next volume will provide much fresh material, these early records are essential to a complete knowledge of the subject. In selecting and compiling them the author decided to err, if at all, on the side of fullness. What may seem unimportant now may have a new value in the light of fresh evidence, and it seems better on general grounds to publish all the records, having once extracted them.

Cochin,
February 1938.

R. C. BRISTOW.

CHAPTER II

EXTRACTS FROM THE

MALABAR GAZETEER.

By CHARLES INNES, I. C. S.,

(Sometime Collector of Malabar)

Now SIR CHARLES INNES, K. C. S. I., C. I. E., I. C. S. (retired),

EDITED BY

F. B. EVANS, C. S. I., I. C. S. (retired).

(Sometime Collector of Malabar).

CHAPTER II

The seaboard of Malabar trends north-north-west by south-south-east throughout its length of 150 miles. Cochin boasts the only harbour worthy of the name; and, though ships of shallow draught can cross the bars of one or two rivers, the coast affords scanty shelter to shipping against the gales of the south-west monsoon. There is no deep water close in shore: the muddy bottom shelves gradually for thirty to forty miles from the coast to a depth of 100 fathoms, whence it drops suddenly to 1,000 fathoms; but except for Sacrifice rock, about eight miles out to sea off the mouth of the Kotta river, and the dangerous reefs at Calicut, Tellicherry and Tangasseri, navigation is not complicated by hidden rocks. The littoral current flows from south to north in the south-west monsoon, and southwards at other times.* It is strong from May to October, and traces of a long battle for supremacy between land and sea are everywhere visible. North of Calicut, the coastline as far as the solitary eminence of Mount Deli, is fringed with low cliffs alternating with reaches of sand, and denuded headlands and bays hallowed out by the waves of their southward side, betray the action of the ocean current. South of Calicut, the shore is one unbroken stretch of sand partly thrown up by the waves, partly formed by alluvial deposits brought down by the rivers and backwaters. There is reason to believe that two thousand years ago, the eastern shore of the backwater from Cranganur nearly to Quilon, was the coastline of the country; but, if this be so, the sea has since been claiming its own again. Tradition tells of a church buried out to sea some hundred yards west of Vypeen on the north bank of the Cochin river, and on the south bank the process of erosion is going on steadily year by year.* Hamilton's story of a "sunken town built by the Portuguese" on Coote's reef off Calicut, lacks confirmation; but there is no doubt that the sea now covers what was once the site of the tomb of the Arab Priest, Shaikh Mammu Koya.

The coast Line.

* Note by Administrative Officer.

These statements need qualification.

Islands. The Laccadives, 'the hundred thousand islands' attached to Malabar, lie at a distance varying between 139 and 218 miles of the coast, and consist of a group of four inhabited and ten uninhabited islands. They lie generally north and south in a crescent shape, with usually a shallow lagoon enclosed by a reef on the western and north-western sides. They are coral formations, and their highest points are not more than thirty feet above sea level. They are covered with dense masses of vegetation, consisting in the cultivated parts of cocoanuts, with a few jack and lime trees, and elsewhere of screw pine and scrubby undergrowth. Minicoy, with its dependent quarantine islet of Viringilli, lies further south at a distance of 243 miles from Calicut. In general appearance, it is similar to the Laccadives; but the inhabitants speak Mahl, and the island is really an offshoot of the Maldive group.

Mud Banks. The mud banks that occur at rare intervals along the seaboard from the Kotta river to Cape Comorin, are peculiar to this part of the west coast of India, and from time immemorial, have been known to mariners as safe and smooth anchorages, even in the gales of the south-west monsoon. The most famous are the banks at Alleppey in Travancore and at Narrakal just north of Cochin; but there are smaller banks at Calicut and Pantalayini Kollam in Malabar proper. Ordinarily, when the sea is smooth, the banks are discoverable only by soundings for mud. But, with the onset of the monsoon, the bed of mud at the bottom of the sea is stirred up, and the anchorages calm down as if oil had been poured on their waters. The mud itself, which is peculiar and is not found elsewhere along the coast, is dark-green in colour, fine in texture, and oily to the touch. Another curious feature of the banks is that they are not stationary, but are carried slowly along by the littoral currents. The Alleppey bank is peculiar in that at times its smooth surface is disturbed by 'mud volcanoes' or huge cones of mud and water, which come bubbling up from below, often bringing with them dead fish and roots and trunks of trees.

The bank of Alleppey is the only one which has been scientifically investigated, but *Mutatis mutandis* the same explanation holds good for all. The nature of the coast line from Cranganore to Quilon has already been alluded to. The

narrow mouth of the Cochin river is the sole outlet of a long line of backwaters, which, fed by countless streams run parallel with the sea for a hundred miles and more, and are only separated from it by a strip of sand. At Alleppey, beneath the sand and an underlying stratum of chocolate-coloured sandstone, boring has revealed a layer of mud of precisely the same nature as that found in the sea outside the town, and the connection between the two is obvious. In the monsoon, when the rivers come down in flood and the pressure increases, the swollen backwaters are driven to find another egress to the sea. A subterranean river forces its way through the yielding mud below Alleppey, and, carrying part of it along in its impetuous course, forms the mud banks off the town. Similar subterranean rivers and substrata of mud must lie below Narrakal, Calicut and Pantalayini Kollam, and the absence of 'mud volcanoes' is due to the fact that they lie nearer to the mouths of rivers, and the pressure of water in the neighbouring lagoons is less. The tranquillising effect of the mud is due to the oil therein. Samples sent for assay to the laboratory of the Geological Survey at Calcutta, 'when subjected to distillation, gave brownish-yellow oily matter lighter than water and looking not unlike petroleum.' The oil is derived partly no doubt, from the decomposition of organic matter in the mud, and is also possibly generated under the influence of moderate heat in the subjacent lignitiferous deposits belonging presumably to Warkilli Strata.*

Their origin

The suffocation of the fish in heavy monsoons, when the Alleppey bank is violently stirred up, possibly connects the banks with another curious and unexplained phenomenon often observed in Malabar, which is locally known as the *Ketta vellam* or stinking water. At various periods of the year, but chiefly towards the close of the rains, the sea and some of the backwaters exhale very offensive effluvia. The water is at times of a dark porter colour, at other times it leaves a deposit of black mud on the sand. It is invariably fatal to fishes of all sorts, which float dead and dying on the surface, and are thrown up in thousands by the waves upon the beach. Local fishermen, believe that in seasons when the monsoon is weak, the stagnant backwaters are poisoned by the

Ketta Vallam.

* Note by Administrative Officer.

Some of the above statements probably need qualification.

emptying of the pits, in which the husks of cocoanuts are left to rot in mud and water for months together.

Soils.

Geologically, the plains of Malabar consist for the most part of a low laterite tableland, fringed on the seaward side by a narrow belt of recent alluvial formations. Except for a thin line of arenaceous soil, on the very shore of the sea in some of the coast taluks, the soils of this part of the district belong, without exception, to the red ferruginous series, and are composed of a mixture of clay and river sand in varying proportions. The percentages borne by each class of soil to the total area of each taluk, are exhibited in the following table:—

	Red Ferruginous series			Arenaceous series
	Clay	Loam	Sand	
Chirakkal ..	1·85	89·75	8·40	..
Kottayam ..	·47	96·80	2·73	.
Kurumbranad ..	1·20	85·91	11·33	1·56
Calicut ..	·15	92·25	6·87	·73
Eranad ..	·52	94·03	5·40	·05
Walavanad ..	·01	83·04	16·95	..
Palghat ..	...	90·40	9·60	..
Ponnani ..	4·15	39·89	51·06	4·90
Cochin ..	8·8	2·7	88·5	..

CHAPTER III

THE REPORTS OF

JOHN CASTOR Esquire, Master Mariner,

and sometime Master Attendant at the Port of Cochin,

together with appendices and the covering remarks of

other Government officers.

CHAPTER III

MARINE DEPARTMENT

Proceedings of the Madras Government

Read the following letter from J. J. Franklin Esq., Superintendent of Marine; to T. Pycroft Esq., Chief Secretary to Government, Fort Saint George, dated 17th July 1861, No. 2047.

I have the honour to forward for the consideration of Government, a very interesting report from Captain Castor, Master Attendant at Cochin, of the formation of a mud bank about five miles to the north of that port, which, like the one existing at Alleppey has the effect of breaking the force of the ocean swell even in the height of the monsoon, and on which vessels can anchor during the worst season of the year, as far as is now known, in perfect safety.

2. It seems strange that a place like this should have existed for so many years, at such a short distance from the much frequented port of Cochin, without having been known to the local authorities or the local shipping community, but the testimony of Captain Castor, who is an exceedingly intelligent Officer, is conclusive as to the absence of all surf or even of any ripple on the beach during his several visits to the spot in the south-west monsoon when a heavy sea was breaking on each side to the north and to the south of it.

3. Mr. Grant, the Collector of Malabar, recommends that a scientific Naval Officer should be at once sent to examine the mud bank whilst the monsoon is at its height, as he would then have the opportunity of ascertaining its value as a landing port under the most trying circumstances. This point is a matter of the utmost importance in connexion with the landing and shipment of mails and passengers during that season of the year, when the Malabar Coast is generally closed to navigation. I think however, that Captain Castor is fully competent to conduct this inquiry, and as he resides within a few miles of the spot, I would suggest that I be permitted to instruct him to proceed

there at the public expense on the occasion of any unusually heavy weather during the present monsoon, and report on the state of the sea in the roadstead as well as on the shore. The coast has already been surveyed and the bank laid down. All that we require now is to ascertain whether during the strong monsoon breezes, the sea remains smooth enough for vessels to lie in safety and for communication to be kept up with the shore. Captain Castor, as a thorough sailor and with his local knowledge, is well qualified to furnish a trustworthy report on the matter.

4. Should the report herein contemplated prove Narrakal to be a fit place for anchorage during the south-west monsoon, I will then address Government as to the means which it may be advisable to adopt to indicate the most favourable position for vessels to occupy.

From John Castor Esq., Master Attendant at Cochin, to P. Grant Esq., Collector of Malabar, Calicut, dated 6th July 1861, No. 201.

I have the honour to bring to your notice some interesting particulars with reference to a place on the coast situated about five miles to the north of British Cochin, and in the Cochin Rajah's territory.

2. Considering how few places there are on this part of the coast, capable of affording shelter to vessels in distress during the prevalence of the S. W. monsoon, it is no unimportant matter to the toiling Mariner to know that on this unsheltered coast there is a mud-flat, within sight of this port, where, though exposed to the winds blowing from one half of the compass, he could ride with perfect safety under all circumstances, refit, discharge and load, when this harbour is shut to him.

3. In order to appreciate the necessity of such a place of safety, one has only to run his eye over the chart of this coast, to be instructed how little nature has done in forming places of refuge capable of receiving any class of vessels at all times.

4. Though rumour of a vague nature had previously reached me, in respect to the existence of the mud-flat above alluded

to, my attention was particularly drawn to it by a recent occurrence.

5. A vessel in these roads, being unable to maintain her communication with the shore, owing to a heavy sea on the bar, her Commander after a personal visit to the place, proceeded with the vessel to the mud-flat, with a view of testing its capabilities, and it was while she was there, discharging her cargo, that I paid my first visit to the locality.

6. On my arriving at the spot, and witnessing the quiescent state of the sea, without a murmur, without a ripple, I could scarcely realize the fact that I was standing on the shores of the Indian ocean in the height of the S. W. monsoon.

7. From the notes taken, and observations made during several visits, I beg to submit the following report of the place. From so short an examination, extending over a few hours on each visit, this report cannot be expected to be so complete as I could wish.

8. The mud-flat commences half a mile south of a village called Narrakal, which is situated about five miles from the port of Cochin, and extends northward along the coast, to about four miles; but the greatest stillness and the total absence of surf on the beach prevail between a village called Nairambolom and Narrakal, the former being about 1½ miles north of the latter. The extent of land which separates the sea from the back-water is about half a mile.

9. The beach opposite to Narrakal is sandy to the margin of the water, but the soft mud begins immediately from this line to seaward; the shore abreast of Nairambolom is formed of an extensive mud bank (an unusual feature of a sea beach), running in shore about 200 yards from the sea, and very inconvenient for landing or embarking, as the boats have to be dragged through the mud.

10. The stratum on the shore fronting the mud-flat abreast of Narrakal, is composed of a crust of sand to several feet deep, then it is slightly mixed with mud; but off Nairambolom, there

seem to be two strata, superposing each other; the lower stratum being mud several feet deep, and the upper, sand intermixed with mud. On the flat itself, the stratum is composed wholly of mud.

11. On all occasions that I visited the locality, I embarked from the beach, and put out to sea in a small canoe, for the purpose of taking soundings. The depths on this flat are regular and gradual, with very soft bottom, and offering no resistance to a 7 lb. lead which penetrated in some parts to three feet, in depths of six, to ten feet water; and from the lead barely intimating its contact with the bottom it required very close attention to obtain accurate soundings. A bamboo penetrated 6 feet into the mud, in a depth of 6 feet water. Beyond a depth of 16 feet, however, the nature of the bottom attains greater consistency, and appears good holding ground.

12. At a distance of about three miles from shore, the depth I obtained was from 5 to 5½ fathoms; and this depth gradually shoals as the shore is approached, but the decrease is so slow as to be imperceptible till a considerable distance has been traversed.

13. At the depth of five fathoms, an easy motion was experienced, but as the swell advances towards the shore, it subsides and entirely disappears, on a calm day, in 18 feet; not even exhausting itself in the smallest ripple on the beach. It was remarkable that, while on the contiguous parts of the coast, a most turbulent sea was breaking, so that no boats dared venture out, here, the fishermen pursued their daily occupations in perfect safety, as if upon a lake.

14. It is further worthy of observation, that the long rolling ocean swell, driven by a furious monsoon, and breaking with such percussive power hard by, should lose itself and imperceptibly disappear as it approaches the flat. Various are the causes assigned to this phenomenon, but it would be undesirable to discuss the point here.

15. As sea beaches are in a constant state of change, and ruin, and are governed by laws of nature which materially

disturb them; I spared no pains in making diligent and searching enquiries of fishermen, and respectable natives of villages before alluded to, as to how long the sea has ceased from breaking on the beach, and the deposits of mud had existed.

16. Some of my informants, who were old residents of the place, bore testimony as to their remembrance of the existence of the mud-flat since their boyhood. Others again, dated its appearance from a later period, some from 20, and some 30 years; but all agree as to the stillness of the sea, and the absence of breakers, in all weathers, and winds from all quarters. I may further add, that the only thing they alleged to have observed was that the sea advanced and receded occasionally; and in some places to the north of this flat, considerable ground had been left permanently uncovered, and where cocoanut plantations are now thriving. But this action of nature is visible in other places.

17. Such are the leading features of this mud-flat, as they have presented themselves to me. I must state, however, that my observations were hitherto made in moderate weather, excepting so far as the sea was concerned, having invariably selected a day when the sea was high at Cochin and the adjacent coast. It remains therefore to view the place during the prevalence of heavy winds, and to keep it under observation throughout the monsoon.

18. In the south-west monsoon, when communication with Cochin is rendered difficult or impracticable; or, on the approach of bad weather, when it is desirable that vessels should leave the port, this mud-flat would be found a place of great security and convenience; and uninterrupted communication could be maintained with it by land, or backwater, at a run of an hour and a half from Cochin.

19. Although the vessels at anchor here will be exposed to the full force of the monsoon, they will ride smooth and safe; and should they by any misfortune be driven on shore, no injury can be sustained by ships getting on a soft mud bank, where there is no sea or surf; and they can easily be floated off again.

The gales which visit Cochin are not so severe as those which blow higher up the coast or in the Bay of Bengal.

20. I have refrained, for the present, from giving any directions by which vessels could take up a good berth on the flat, in bad weather. My attention hitherto was more confined to the soundings, and the nature of the ground, than to any bearings of objects by which vessels can safely run in and anchor. The Cochin flagstaff before being struck, is clearly visible from the flat and will afford a good guide by day; and its light which is also visible, will be of great service to vessels wishing to avail themselves of the place in the south-west monsoon.

21. The frequent setting-in of the monsoon before the completion of the Shipping operations of the season, compels the Merchants to send their vessels to the neighbouring port of, Alleppey a distance of thirty miles, to complete their cargoes, which are conveyed there by backwater, at great expense and inconvenience to the shipper. For the vexatious detentions at the different backwater Chowkies, and the duties payable to both Native Governments, are sources of great hardship. These difficulties will now to a great extent be modified, and Narakkal resorted to instead of Alleppey for such purposes.

22. As there are no prominent objects by which the place could be distinguished, I would respectfully suggest that a masonry pillar, or obelisk, be erected on the beach, on a spot hereafter to be fixed, as a guide for the anchorage, and a flag displayed from a staff to be fixed on the column. As the Cochin Sirkar will derive much benefit from vessels resorting to the place, the question by whom the cost of erection will have to be borne, will be a matter for consideration by higher authority.

23. When by the completion of the Railway from coast to coast, Madras will be brought within a few hours of Beypore, I trust. it will not be thought foreign to my present province, to offer a few remarks on the advantages arising, from the Malabar coast being made the point of arrival and departure of the Overland Mail Steamers.

24. It has been said that Beypore could be used for 8 or 9 months in the year, and that in the height of the south-west

monsoon the communication with the shore is neither open nor practicable: on this account, the landing of Mails and passengers on this coast is objected to.

25. The supposed difficulties against this coast, being fixed as the next point of land to be made from the Arabian shore, will be removed when the fact is known, that at such periods when Beypore is shut there is another point involving but a trifling divergence from their course, * where the Steamers can touch with perfect safety, and effect their purpose.

*20 miles.

26. I cannot speak from any personal knowledge of the port of Beypore. But if it could be made use of, for three-fourths of the year, as it is stated in official papers, Narakkal might be availed of for the remaining period, as it is possesses the advantage of a ship-building port in close proximity, offering every convenience and facility in case of need.

27. This arrangement will be open to the objection that it will create a detention of twenty-four hours, in reaching the Railway Station at Shoranur, (distance about 50 miles) by back-water. This detention would in a great measure be balanced by that now incurred at Galle. When Steamers do not reach that port before dark, * they remain out all night, and are exposed to a heavy sea in the south-west monsoon, while here, they would be able to run into smooth water and anchor for the night, and the danger of going in and out of Galle harbour be avoided.

*Mails and passengers could land at Narakkal at all hours of the night.

28. It will be observed, that I have assumed twenty-four hours as the probable detention of meeting the Railway at Shoranur, when Beypore is not used; but this period might be very considerably reduced by improved back-water communication.

29. It now remains to be shewn, what advantage will be gained by adopting a direct line in preference to the circuitous route round Ceylon. The distance from Aden to Madras, is at all times, 2,700 miles; but from Madras to Aden, in the

southwest monsoon, (I assume that the Mail boats adopt the route through the one and half degree channel) is 3,000 miles; and this distance, I believe, is performed for four months in the year, or from the beginning of May to the end of August.

30. The distance from Aden to Beypore is, at all times, 1,830 miles; and Beypore to Aden in the south-west monsoon is 2,000 miles.

31. The distance then, that would be saved by the Suez Steamers touching at Beypore, instead of adopting the Ceylon route, would be 870 geographical miles, or four days actual steaming, at an average rate of 9 knots per hour, with some allowance, of course, as the monsoons may be prevailing.

32. The overland transit by rail is next to be considered. I presume this will occupy 24 hours, and if the present detention at Galle, which varies according to circumstances, is taken into account, the mails will reach Madras 3½ to 4 days earlier than at present.

33. The result in the south-west monsoon in the case of the outgoing Steamer, would be still more favourable. The distance saved would be 1,000 miles, or nearly 4¾ days steaming.

34. There will, of course, be a subsidiary Steamer at Madras to take on the mails and passengers to Calcutta.

35. If the saving of 3 or 4 days in receiving intelligence from England is of such unquestionable importance to the Government and the Public, it is not without corresponding advantage to the P. and O. Company, as carriers, as the following rough estimate will shew.

36. The present number of Steamers on the Calcutta line, annually, is 48. The saving in the difference between the present and the present and the proposed route, in round numbers, would be

48 trips, saving 4 days on each trip, or 192 days at 35 tons Coal per day at 30 Rupees . . Rupees 201,600.

At the above very moderate computation, the result shews an annual saving in coal alone of upwards of 20,000 £ to the

P. & O. Company, to say nothing of other minor items of expenditure which amount to a considerable sum in the aggregate, and this too by avoiding the inconveniences of the present route, and lessening the wear and tear of their vessels.

37. With respect to the Ceylon mails, brought by the Overland Steamers, there can be no difficulty in arranging for their transmission from Beypore by the Bombay Steamers proceeding twice a month to China touching at Galle. At all events such an arrangement can be attended with no obstacle sufficiently cogent to necessitate the abandonment of so important an advantage as the saving of about 4 days in the conveyance of the mails from England to India.

38. Again, an argument may possibly be raised against the proposed route, on the ground that Ceylon will lose the advantage of receiving her mails near Colombo, and as early as now. The same objection would equally apply to a proposal recently made to give up Galle and land the mails at Trincomallee. All material inconvenience could, I conceive, be avoided by sending the mails from Beypore direct to Colombo in a small Steamer.

39. It would be needless at present to enter into the minor arrangements, which will become necessary by the adoption of the course proposed, as they might be conveniently left to be discussed hereafter. I may however, mention that, in my opinion, the alteration under notice will be attended with little or no expense to the State, beyond perhaps a small floating light vessel, a good wharf, and a few boats adapted for the work, involving a sum altogether insignificant when the hastening of the mails is considered.

40. There can be no doubt that the advantage will be immense to the Government and the Public who are deeply interested in the establishment of speedier communication with England; while to the P. & O. Company, will accrue a substantial saving of fuel, and other items of expense, and not least, the lessening of the danger and risk of a long and circuitous route, and this at a juncture when they are unexpectedly

called upon to enter into a formidable competition with a new Company, of a foreign nation, subsidized by their Government.

41. Although the question as to the expediency of the change herein advocated, must of course be fully discussed by those who are more capable of judging in the case, it may not be out of place to observe, that, as far as the route between the Malabar and Arabian coasts, and the practicability of landing the mails throughout the year on this coast, affect the question, I believe there is not the slightest obstacle or difficulty.

42. I beg you will be pleased to submit this report to the Superintendent of Marine, for eventual submission to Government, if that Officer deems it desirable.

Order thereon, 26th July 1861, No 242.

His Excellency the Governor in Council has attentively perused Captain Castor's very interesting letter to the Collector of Malabar, on the subject of the mud bank, similar to that off Alleppey, discovered five miles to the north of Cochin; and considers it of great importance that an observation should be made as to the state of the sea at that spot in very boisterous weather during the present monsoon on that coast. The Superintendent of Marine will instruct Captain Castor accordingly. His expenses, while so employed, will be reimbursed to him.

2. A copy of these Proceedings will be forwarded to the Resident of Travancore and Cochin.

(True extract).

Note by the Administrative Officer and Harbour Engineer-in-Chief.

It is rather remarkable that the P. & O. Passenger Boats were calling at Cochin between January and May 1857 and were apparently moored not over the mudbank but elsewhere. Possibly it was a burst of rough weather in May 1857 which led to the discontinuance of the service, for Captain Castor seems to have known nothing about it in 1860—1861. (See Fort St.

George Gazette, Cochin, 13th December, 1856, and "Cochin Eighty Years Ago" by "Davy Jones" in the "Madras Mail", 16th January 1938.

From J. J. Franklin, Esq., Superintendent of Marine, to T. Pycroft, Esq., Chief Secretary to Government, Marine Department, Fort Saint George, dated 25th November 1861, No. 3300.

I have the honour to inform you that, in compliance with the 1st paragraph of the Order recorded in Proceedings of Government of the 26th July last, No. 242, I forwarded to the Master Attendant at Cochin, instructions, copy of which is appended, regarding the examination of the mud bank off Narrakal. The report just received is likewise forwarded; and as I look upon it as containing information of the greatest importance to the Maritime community, I beg to recommend that it be published with the previous papers, for the purpose of being furnished to the Chief Marine authorities at all Indian Ports. It ought also to be made generally known at the India House, for the information of Commanders of ships bound to India.

2. The facts brought to light by Captain Castor, who has evidently bestowed great pains on the investigation, are, that about half a mile south of the village of Narrakkal, which is situated about five miles north of Cochin, a bank of very soft mud commences and continues some four or five miles in a northerly direction, extending to seaward about three miles, with soundings gradually increasing to five fathoms; that upon this bank, during the heaviest weather that has been experienced during the past monsoon, (which, however, was a moderate one,) a perfectly smooth sea reigned in three fathoms, and that in five fathoms, only a gentle undulation was experienced, insufficient to endanger in the slightest degree even small boats; that the bottom throughout is good holding ground, and that on the shore, while a heavy surf was breaking north and south of this favoured spot and the Cochin bar impassable, not a ripple was to be observed.

3. It appears moreover that, although the European community at and near Cochin were not aware of the advantages that existed so close to them, they had long been well known to the neighbouring fishermen and the natives navigating the coast. The extract from the old Dutch work describing a voyage to the various parts of the Indian seas in 1774 to 1778, quoted in the 15th paragraph of Captain Castor's report, likewise shows that the same peculiarities, although since modified, existed nearly a century ago. It may therefore be reasonably expected, that whatever change does take place will be very gradual, and that for present purposes the bank may be considered stationary.

4. These points being admitted, it remains to be considered what steps should be taken to render the place as useful as possible.

5. During the fine season on the Malabar Coast, or from September to April inclusive, the sea is generally very smooth, and little difficulty exists in conducting shipping transactions at Cochin. All the mercantile firms being settled there, I doubt whether they would care to have their shipping operations removed to a distance of five or six miles from their immediate supervision, and moreover there is this objection to any attempt at present, at any rate, to transfer the port of Cochin to Narrakkal, that it is situated in the territory of the Raja of Cochin. But it frequently occurs that vessels, either through ignorance, or from having made longer or shorter passages than expected, come on the coast during the south-west monsoon which prevails during the remainder of the year, and when frequently a mountainous and always a heavy sea is running. Other vessels are also often backward in loading or unloading in Cochin roads and similarly find themselves on a dangerous coast. To these, some few facilities to enable them to take advantage of the safety afforded by the Narrakkal mud bank would be most serviceable, and for the present, I think, we may confine ourselves to this.

6. I would propose therefore that a white obelisk, about forty feet high, should be built on a spot to be selected by Captain Cast somewhere abreast of the best anchorage, that directions for anchoring should drawn up by the same officer;

and as the water is very shoal towards the beach, that a small wooden jetty on piles be constructed to enable boats drawing two or three feet, to load and unload alongside.

From J. J. Franklin, Esq., Superintendent of Marine, to Captain Castor, Master Attendant, Cochin, dated 1st August 1861, No. 2188.

In forwarding you a copy of the Proceedings of Government of the 26th ultimo, No. 242, on the subject of your report on the anchorage off Narrakal, I have to request that you will make a point of visiting that place during the remainder of the present monsoon on any occasion of a strong breeze or gale. Any expenses while so employed will be allowed.

2. In the event, however, of any ship being in distress at Cochin and requiring your services, you will of course postpone your visit to Narrakal until the necessity for the delay has passed.

3. The principal points which you will be required to report upon will be—first, the condition of the sea in four to five fathoms during heavy monsoon weather, and the state of the beach at similar times, noting whether the limits of smooth water alter with a shift of wind or current. I notice in Lieutenant Selby's Chart, copy of which is in your office, that two fathoms and in one place as little as one fathom is marked on the bank at a distance of 1½ miles from the newly formed sea beach. To render the anchorage secure, it will not be sufficient that the sea should subside here, its force must be broken further out.

4. From the nature of the formation and the fact of its not having been generally known although so near to Cochin, I conclude that it is of recent origin, perhaps more recent than stated by the fishermen, who, in common with other natives, are vague on the subject of dates: and being recent, it is probably still extending. You will endeavour to obtain the best information on this point from the natives on the spot, and with Lieutenant Selby's Survey, which was executed in 1851—53, might be able to detect whether it had increased much during the intervening time.

5. With these observations I leave it to you to carry out the orders of Government, feeling confident that you will not fail in affording the fullest information in your power.

(True copy)

(Signed) J. J. FRANKLIN,

Superintendent of Marine.

From Captain John Castor, Master Attendant, to J. J. Franklin, Esq., Superintendent of Marine, Madras, dated Cochin, 16th November 1861, No. 306.

In obedience to the Order of Government, dated 26th July 1861, No. 242, conveyed to me in your letter of instructions, dated 1st August, No. 2188, I have the honour to submit a Supplemental Report on the anchorage of Narrakal.

2. During the south-west monsoon just passed, the place was visited by me on every occasion the weather was in any way disturbed, so as to afford me an opportunity of observing the state of the sea, and other peculiarities on the mud bank.

3. Before I proceed to notice the facts which came under my observation, I must record the circumstance, which is not without some importance, that the monsoon this year has been one of unusual mildness, so far as it has reference to the force of the wind, although the sea has been frequently very high.

4. My particular attention was directed to the condition of the sea from three to five fathoms, the water below three fathoms having invariably retained its stillness. Between the two depths before-mentioned, the water is comparatively smooth. There was a little swell, though neither its force nor its height would have disturbed even a small vessel at anchor.

5. It is in a W. N. W. direction from the village of Narrakal, that the sea subsides in the depths I have named ; but to the south, the bank being narrower, the deep water, as well as the stillness are at a less distance from shore, and to the north, the water is shallower, and smooth further out to sea.

6. In the ordinary course of professional observation, I would have pronounced the anchorage in the depths mentioned

smooth, and the little swell which has been perceptible to a close and continued scrutiny, would have passed unnoticed by a casual Mariner anchoring on the ground on an open coast.

7. The beach, on every occasion I visited the spot, was perfectly still, and beyond what the wind would create on a lake or tank, there was nothing remarkable; but there was no surf or sea arising from the ocean swell thrown on the beach, as in other parts of sea shores.

8. Whether the limits of smooth water alter with any shift of wind or current, I regret the mild state of the monsoon, and the absence of violent shifts of wind, afforded me no opportunity of observing. The water appears smoother during the ebb than the flood tides. When the sea rages high on the adjacent shores, the formation and extent of the bank are clearly defined by the rising swell without the limits, contrasting greatly with the smooth surface of the water within.

9. There appears to be a singular feature in connection with this locality, which is worthy of note, though it would be desirable to keep it under observation with a view to further elucidation. The more turbulent the sea became in the contiguous parts, the greater stillness seemed to prevail on this bank. This peculiarity not only presented itself to me but to others who visited the spot, and attracted the attention of the Commander of the "John Cobbold," to which ship allusion was made in my former report. The only way this phenomenon could be accounted for, is by the turbulence of the surrounding sea disturbing the mud in suspension, and increasing the density of the water on the bank.

10. The soundings I obtained, differ somewhat from those marked in Lieutenant Selby's Chart. I have been very carefully over a large extent, within the space of the dotted line, embracing the anchorage of Narrakal; but my efforts to discover the spot marked one and two fathoms, 1½ miles from the shore, have proved unsuccessful.

11. From further inquiries, I find that the existence of the bank is more generally known than, at first, I was led to believe. The Syrangs and Tindals of coasting craft, with whom I have

conversed on the subject, state that its still anchorage has been known among them for years, and is commonly resorted to during gales of wind. Without exception they all bear testimony to the total absence of surf on the beach, and the safety and security which the place affords.

12. The statements of the natives and fishermen, residents of the place, confirm those of the coasting seamen; but on questioning them as to the limits of smooth water in very heavy weather, their replies are vague and unsatisfactory. This probably is owing to their not venturing out in very bad weather, and the usual indefiniteness of this class of men on subjects requiring close observation. But to the still condition of the beach in all weathers, the evidence is unanimous and conclusive.

13. The question as to whether the bank is of recent formation, or of long existence, being one of vital importance to the subject in its future bearings, I have gathered the fullest information I could obtain. Living witnesses not only confirm its duration to thirty years back, but show its advantages as a place of refuge.

The depositions * which accompany this letter will bear out these facts. I must be permitted at the same time to embody two references, one of recent and another of older date, tending to prove the existence of this bank at a remote period.

*Six in number.

14. The late Captain Biden, who was ever watchful on matters tending to promote the interests of navigation, on his visit to this coast in 1841, must have had his attention drawn to the subject of the bank; for among the recorded inquiries made by him on that occasion, in connection with Cochin, I find the following:—

Q.—"There is said to be a particular sort of mud bank parallel with the coast, and near Cochin, on which vessels may anchor in stress of weather, and if they part from their anchors, the nature of the ground is such, that they will suffer no material injury if they drift on shore upon the mud; I have heard that a large ship was disabled and rode out some blowing weather on

this bank and was re-fitted there, where is the bank? What distance from Cochin and what is its extent, the soundings indicated thereon, etc.?"

The subjoined reply was furnished by the late Fiscal.

A.—"This bank is situated at Pooryapoolly about nine miles to the north within the Cochin Sirkar's territories, the extent of it is about six miles, and the soundings from one to seven fathoms".

15. The other reference is from the translation of an old work* written by a Dutch Navigator who traded with this coast between the years of 1774—78. In a description of Cochin and its neighbourhood, I find the following notice with reference to this bank:—

*Voyage to the Cape of Good Hope, Batavia, Samarange, Surat, East Indies, etc., etc., in the year 1774—78, Book III, Chapter 12.

"The coast is safe and clear everywhere along the Company's establishment, except at the mouth of the river of Cranganur. South of the above mentioned mouth of the river of Cranganur there is a bay formed of mud banks; the banks forming which extend full a league out to sea, and into which vessels may run with safety during the bad monsoon, and may lie in twenty and less feet water, almost without anchors or cables, in perfect security against the heavy seas which then roll in upon this lee-shore, as they break their force upon the soft mud banks, and within them, nothing but a slight motion is perceived."

16. I find an allusion to the Alleppey bank in a work descriptive of this coast entitled "A new History* of the East Indies," by Captain Cope, published in London in 1755. I cannot refrain from quoting the passage, though not bearing directly on the bank under notice, as it proves the existence for at least a century of a bank similar in its general features to the one in question, and affords strong collateral evidence of the permanent effects of these mud formations:—

*A new History of the East Indies, by Captain Cope, published in London in 1755.

"Mud Bay is a place, that, I believe, few can parallel in the world. It lies on the shore of St. Andrea,* about half a league out in the sea, and is open to the wide ocean and has neither island nor bank to break off the force of the billows, which come rolling with great violence on all other parts of the coast, in the south-west monsoons, but, on this bank of mud, lose themselves in a moment, and ships lie on it, as secure as in the best harbour, without motion or disturbance. It reaches about a mile along shore, and has shifted from the northward, in thirty years, about three miles."

*St. Andrea is situated about six miles from Alleppey.

17. By Lieutenant Selby's survey in 1851—53, and the information I obtained from the natives of the place, I find that the bank has somewhat shifted to the southward; and the Bay alluded to in the account given in 1778; in all probability, is the ground recovered by the recedence of the sea, and the shifting of the bank, and which is now occupied by paddy fields and cocoanut plantations.

18. The Alleppey bank is said, whether correctly or not I cannot affirm, to have shifted a little to the southward. But the much further advance of the one at Narakkal in the same direction is a matter of less likelihood, from the following circumstance:—Situated as it is, in close proximity to an estuary which discharges an immense volume of water to the northward and westward, I am inclined to the opinion, not without a strong probability in its favour, that this tidal stream, so impetuous during the greater period of the year, will arrest any considerable progress towards the south.

19. The long existence of the bank can now scarcely be doubted, supported as it is on reliable testimony derived from various sources, and written at different periods, extending even to the last century. Its future permanency can safely be inferred from its past duration; and the induction is strengthened by the almost undisturbed existence, from a remote date, of a similar phenomenon within the same degree of latitude, resembling each other in their general characteristics, and exposed to the same external influences.

20. I will take the liberty of submitting, as arising out of this inquiry, a few observations regarding the anchorage of Narrakal. As a rule, the greatest difficulty and danger experienced in all open roadsteads, where the beach is subject to the action of the surf, is in landing and embarking; but when once over the range of the surf, the danger and difficulty are comparatively surmounted. The communication with the shore is generally interrupted, not so much by the height or force of the swell in the roadstead, as by the dangers of the surf at the point of landing and embarking. Where these dangers are entirely absent, as at Narrakal, the mere existence of a swell in the anchoring depths, even should it prevail, cannot tend seriously to disturb shipping operations.

21. Again, even when a high sea prevails in an anchorage, the danger to boats is remote unless there is broken water; but as heavy crested waves have never been seen on this bank, in the depths alluded to, as far as my observation goes, it forms an additional security to free and safe communication.

22. In a gale of wind, it would be difficult to assert with safety that the limits of smooth water would be strictly preserved. Experience demonstrates that a sea may be created by the violence of a hurricane or a gale, even in comparatively sheltered harbours, and should the same effects be produced here by a like cause, they should not of themselves form an objection to the place, considering the general security of the anchorage and the stillness of the beach in all weathers. In the event of serious accidents, the place will still, from the nature of the ground, offer the same security to life and property, that a sheltered harbour would under similar circumstances.

23. I beg to conclude this report by soliciting your attention to the accompanying papers, marginally noted, consisting of original letters from various Commanders of ships in this port during the S. W. monsoon; extracts of a Journal kept by me during my visits to Narrakal; and a tabular statement of the depths with their respective distances from shore.

Cover marked A contains six original letters. C. Extracts Master Attendant's Journal. D. Tabular Statement of depths.

24. I beg to subjoin a chemical analysis of the mud which was taken from the bank, and sent to Madras. I am indebted to Captain Mitchell, in charge of the Madras Government Central Museum, for the information.

From Lieutenant J. Mitchell, Officer in charge of the Government Central Museum, to Captain J. Castor, Master Attendant, Cochin, dated 17th October 1861, No. 116.

I have the honour to acknowledge, with my best thanks, the receipt this morning of the bottle of mud from the Narrakal bank.

2. Between the despatch of my first letter and the receipt of your reply, a small quantity (about half a cubic inch) of the mud was sent to me for examination; so far as I have ascertained it consists of:—

First.—Very minute angular fragments of quartz, the largest hardly visible without a lens; this is the sand.

Second.—Of Foraminferous shells of the genus Rotalia, and a few fragments of larger shells.

Third.—Of Diatomacea, of which I have species from upwards of twenty genera.

Fourth.—A few Specules of sponges and corals, very minute; and

Fifth.—Some Amorphous matter which was not destroyed after long boiling in strong acids.

3. The liberal supply just received will doubtless afford many more specimens of the Diatomacea, and perhaps of the Foraminfera besides those named above.

(True copy)

(Signed) JOHN CASTOR,

Master Attendant.

From John L. Renells, Esq., Master of the "John Cobbold," to Captain John Castor, Master Attendant, Cochin, dated 13th June 1861.

In compliance with your request, I have much pleasure to give you a few particulars regarding the place Narrakal abreast

of which, I discharged nearly the whole of my cargo during the prevalence of the south-west monsoon.

I arrived in Cochin on the 22nd May, direct from London, and found great difficulty in getting boats off owing to the heavy sea on the bar, however I managed to discharge about fifty tons of cargo when the sea about the 25th, increased so high, that all communication with the shipping was at an end. Having heard of a place situated six or eight miles to the north of this, where it was said that owing to a mud bank no surf or sea prevailed, and that no difficulty will be experienced in landing my cargo, or remaining at anchor, I was induced, in company with Mr. Peirce, the Agent of the vessel, to visit the place. I was astonished at the pond-like stillness of its shore, and the smooth sea around.

I returned to Cochin, and as no boats could get off to the ship, I signalled to the chief Officer to get underweigh and proceed to the north about six miles, and to stand off and on until I boarded him. I myself proceeded by the back-water to Narrakal and went off to the ship which fell a little to leeward. On the 1st June, I anchored on the mud bank referred to in five fathoms, soft bottom, and discharged the remaining portion of my cargo, with as much ease as if I was lying in the Thames.

During my stay off Narrakal, the weather was very bad at times, blowing in smart squalls with heavy rains; the sea breaking heavy on the adjacent parts of the coast, and no communication could have been held with the ship, were she in Cochin roads. While here I was lying in smooth water, scarcely moving, and discharging my cargo, and landing whenever I wished with the ship's boat, without even going through a ripple.

I have no doubt, from the interest you take in these matters, you will bring the place to the notice of Government, and insure a wide publicity being given to the circumstance that no place on this coast, from Karachi to Cape Comorin, not even excepting Alleppey, affords so safe an anchorage during the south-west monsoon, as the locality I have here described.

As you have visited the place yourself, I will not lengthen this communication by suggesting anything; but leave the whole

matter now in your hands, as I am sure it will receive every attention.

From Mr. T. Regnaud, to Captain J. Castor, Master Attendant, Cochin, dated Vypeen, 5th July 1861.

Having had the pleasure to visit, in your company, that part of the Malabar Coast called Narrakal, I consider it my duty as a Mariner, to convey to you the remarks I have made regarding that place.

Firstly, at my arrival there, I was struck by the contrast existing between the Cochin, Vypeen and Malipuram shores, where the sea breaks heavily, to the smoothness of the sea at Narrakal, not only on the beach, but as far as the eye could see in the offing, though the breeze was pretty fresh blowing from the sea; I was also surprised to see a great number of fishermen in rather small-sized canoes at no less a distance than two or three miles off shore; also on being told that it was a thing of daily occurrence all round the year, the bank being full of fish.

I attribute the quietness of Narrakal roads to the nature of the muddy ground, and therefore strongly recommend it as the best place for vessels to ride at anchor in bad weather, and the only place in the vicinity of our port convenient to land and ship cargo during the south-west monsoon.

No peculiar mark existing inland to warn Mariners of their approach of the place, it would therefore be advisable to exhibit a light on a column, or flagstaff as a guidance.

I must before concluding tell you that the few remarks contained herein are sincere and not the least exaggerated.

The writer of this letter is a French gentleman, formerly Commander of a ship, and now a resident of Cochin, and engaged on mercantile pursuits.

(Signed) J. CASTOR.

From Mr. J. Blundin, Commander of the French Bark "Anjelina," to J. Castor, Esq., Master Attendant, Cochin, dated 12th July 1861.

Having had the pleasure of visiting with you that portion of the Malabar Coast called Narrakal, I think it my duty as passed Captain to bring to your notice the observations which I made at this place.

Immediately upon my arrival there I was astonished at seeing the contrast which exists between the coasts of Cochin, Vypeen and Malipuram, where the sea is constantly very high, rendering the approach impossible, and the smooth sea at Narrakal, not only upon the immediate coast, but as far as the eye can reach. I was also surprised to see the large number of fishing boats of ordinary size, two or three miles from the shore, and to learn that this was the case all the year round, the bank being very abundant of fish.

I attribute the smooth sea in the Port of Narrakal to the mud of which the bottom is composed, and would strongly recommend it to ship Captains as excellent holding ground for anchorage, and the only one in the neighbourhood of Cochin, in which it is possible to load and discharge vessels during the south-west monsoon.

No particular mark exists upon the coast to indicate the approach to the spot to seamen.

It would therefore be most urgent that a light should be exhibited, or that a flagstaff sufficiently high to overtop the cocoanut trees be erected, in order to indicate the anchorage.

In conclusion, I beg to state that the foregoing remarks are offered in all sincerity.

From Thomas Jones, Esq., Master Mariner, Barque "Emu," to Captain John Castor, Master Attendant, Cochin, dated 29th July 1861.

In compliance with your request for me to give you my opinion of the capabilities and advantages of Narrakal, as a

harbour of refuge during the south-west monsoon, I have the honour to inform you,

That in consequence of the reports I had heard circulated, and the many paragraphs in the "Cochin Courier," pro and con. the usefulness of the place, I was induced to make a trip there myself in company with a principal of one of the first Mercantile houses in Cochin, and found to my great surprise, that although the sea was breaking heavily on all the adjacent coast, north and south of it, that the place itself to the extent of about three miles of beach, was perfectly smooth, and scarce a ripple to be seen to seaward.

I consider it to be a most valuable auxiliary to the port of Cochin, during the prevalence of the south-west monsoon, as it is well known that a ship of any considerable draft of water arriving in that season, would not be able to enter the port without lightening, which could not be effected, in the usual way by boats from Cochin, owing to the impracticability of crossing the bar at that season, but might be done very easily at Narakkal, particularly so, if there was a small jetty run out, from twenty to thirty yards, so that three boats might lay alongside and discharge at the same time.

The steam communication between Bombay and Cochin, might also by that means be continued during the whole year, without any interruption from local causes, which I think, would in itself be a great benefit to Cochin.

It being out of place here to give any opinion on the natural phenomena of the place, or the causes of the bituminous appearance of its waters, I leave that to more able and scientific men than myself, to investigate and report upon.

From Captain Thomas Harrison, Commander of the Bark "Glenaln," to Captain Castor, Master Attendant, Cochin, dated 16th August 1861.

Having since my arrival here heard a great deal in favour of Narrakal as a safe anchorage during the S. W. monsoon, and having at your request made a journey to, and examination of the place, I beg leave to lay before you my opinions of its appearance

and utility. On the occasion of my visit on the morning of the 8th instant, a strong surf was rolling at the entrance of Cochin and along the coast as far as the eye could reach, thus affording a tolerably good opportunity of forming a judgment as to the capabilities of Narrakal as an anchorage.

On reaching Narrakal I found the sea perfectly smooth, with scarcely a ripple either on its surface or against the beach, the activity of the waves being completely deadened by a soft mud bank extending a great distance from the shore. At a distance of a mile and a half (measured) W. S. W. from the beach, abreast of the village, at about 2h. flood, I found twenty-five feet water, the bottom of good holding mud, the surface of the water of a very peculiar oily appearance, and a gentle swell from the westward, but nothing to endanger even the fishing canoes, although the surf was breaking heavily along the coast to the southward. In sounding as I pulled off from the beach I found the mud very soft for the first half mile, after which it grew gradually more tenacious as I proceeded seaward. The apparent large extent of the bank to the northward prevented my seeing any surf in that direction, I could see no mark of any sort that might assist in finding Narrakal.

So much for the appearance of the place; now, secondly, as to its utility.

A knowledge of this secure anchorage during bad weather, must be of great value to any Master of a disabled vessel.

I am of opinion that with good ground tackling a vessel might here ride out any storm; or if even parting good cables through force of wind, supposing such a thing possible, might, from the absence of any sea, drive on to the mud with little danger of receiving material injury, and, what is of more importance at such a time, without the dread of losing life.

Boats also containing crews of vessels lost through fire, foundering at sea, or any of the various casualties by which vessels are lost and the crews saved, might land here easily when from surf other parts of the coast are unapproachable.

Vessels bound to, and unable to get into Cochin may land cargo here and send it to its destination by backwater, as I believe was lately done in the case of the "John Cobbold".

Narrakal may, I am firmly of opinion, be made a valuable auxiliary to the port of Cochin, and I can only conclude by saying that I am well pleased at having learned its existence.

The writer of this letter is the Commander of the Bark "Glenaln".

(Signed) J. CASTOR.

From Robert H. Pierce, Esq., to Captain John Castor, Master Attendant, Cochin, dated 23rd August 1861.

I am in receipt of your letter; No. 225, 1861, asking me to furnish you with any information it may be in my power to afford respecting the neighbouring port of Narrakal, and I have much pleasure in complying with your request. Finding it impossible to continue discharging the "John Cobbold" at this place in May last, the Master and myself had come to an agreement to unload her at Alleppey. Having heard, however, some years since that it was frequently quite smooth during our heaviest weather at a point, a little to the northward of Malipuram, I, before the ship left for Alleppey, sent a peon to inspect the state of the coast in the neighbourhood of that place; the account the man gave on his return was so favourable that the Captain at once agreed to accompany me to the place and see if we could turn it to account; we accordingly went there on the morning of the 28th of May, and found the sea so perfectly smooth, and resembling the state of things at Alleppey, that the Captain consented to move up and anchor off the place; he accordingly on returning to this, signalled to the ship to stand up coast six miles and wait for orders; he then went up himself, got a fishing boat and stood off for his ship; in consequence, however, of a strong current to the north, he was some hours in reaching her, this was on the 30th, and he did not anchor till the morning of the 1st June; he informed me that on coming in to where he anchored, he passed through, in six fathoms water,

a broad belt of very thick muddy water; that here he first found the sea losing its force, and that he gradually drew into smooth water, clear but with mud bottom; he lay as quiet as if he were in an harbour during the whole time he was there although outside him, and along the adjacent coast, there was a heavy sea on. I experienced no difficulty whatever from the sea in landing the cargo, but of course had great trouble with the boatmen who had to be taken from this, as well as boats. We landed a great many large tanks on rafts made by lashing two canoes together with a few bamboos as a platform, and not a single accident happened. The sea on the beach was always as smooth as glass, and the Captain was out constantly in his own boat sounding, during the time he was anchored off the place; the ship's long-boat too was left riding at anchor some little distance from the ship all the time she was there. I have had a good deal of experience in shipping at Alleppey during the south-west monsoon, and I consider Narrakal quite equal if not superior to Alleppey, indeed had I had any idea some years since that the bank at Narrakal was so extensive, and afforded such good anchorage and facilities for shipping and landing goods, I should never have used Alleppey. When we paid our first visit to the place, we approached it from Malipuram, the surf on the beach kept getting duller and the water more intensely muddy; as we drew near the bank, the water seemed so heavy and dense with mud that it could not rise and break; and this fact coupled with the observation of Captain Rendle that he passed through a belt of thick muddy water before coming to his anchorage, leads me to conclude that in the density of the sea from the presence of a large body of mud in it, which mud is stirred up on the edge of the bank by the action of the sea itself, we have the real cause of the smooth anchorage, the belt of liquid mud forming a natural and self-acting break-water the more valuable as it becomes more dense, the rougher the weather is outside.

This gentleman represents the Firm of Messrs. Wilson. Ritchie and Co., and was the Agent to the "John Cobbold," which vessel discharged her cargo at Narrakal in June last.

(Signed) J. CASTOR.

I am a Syrang, and I have commanded two or three coasting vessels. I knew the existence of the mud-flat off Narrakal when I was an Apprentice lad to my father, who also was a Syrang out of this port, and I have often been to the place. For the last five years I have been in charge of small vessels myself. During the heavy gale which blew in Cochin in April 1859, I happened to be in the roads, in command of the schooner "Ariel," belonging to Messrs. A. C. Brice and Co., of this port, and parted my best bower chain, I let go a second anchor, which did not hold. I immediately slipped and proceeded to Narrakal and brought up with a kedge and hawser in three fathoms. The water was perfectly smooth in the roads. I landed in a canoe between Nairambolom and Narrakal, in total absence of surf on the beach. The sea was very high on the adjoining coast.

(Signed) BAVA MEERAN,

Cochin, 6th August 1861. Syrang.

During the gale alluded to in this statement, there was a tremendous sea running at the time. I witnessed the Schooner leaving the roads, but was not aware at the time where she ran to find shelter.

(Signed) JOHN CASTOR,

Master Attendant.

Questions put to Mr. D' Aranja, late Fiscal of Cochin, by the Master Attendant, with reference to the mud bank off Narrakal.

Q.—How long back do you remember the mud bank north of this port, off Narrakal?

A.—About twenty-five years.

Q.—Did you ever visit that part of the coast where it is situated?

A.—Yes.

Q.—Did you observe any surf breaking on the beach on the bank?

A.—No.

Q.—Do you remember if any vessels, coasting or otherwise, which sought shelter on this bank during gales of wind or bad weather?

A.—Yes, Pattamars, etc.

Q.—When you first knew the bank, abreast of what village was it?

*Coorpally is about three miles to the north of Narrakal.

A.—This bank, I believe, is situated between *Coorpally and Iyenpally. You will find a canal from the river to the beach. The southern part of this canal is called Coorpally, and the northern, Iyenpally.

Q.—Was the bank ever examined or surveyed by any one, officially or otherwise?

A.—I believe in the year 1841, Captain Biden, the late Master Attendant of Madras, visited Cochin, when, having mentioned to that gentlemen the existence of this bank, Captain Biden, together with Mr. Joaquim de Lemes, (the then Pilot of this Port,) visited the said bank. Mr. Lemes subsequently told me that Captain Biden was much pleased on seeing it, and told him that a ship loaded with coal should be kept there for supplying coals to the steamer.

Q.—Do the fishermen of that part of the coast, where the bank is situated, fish on the bank during the whole of the south-west monsoon?

A.—I was not in the habit of visiting that locality during the south-west monsoon.

Q.—Can you tell into what depth of water, or how far they ventured out?

A.—No. I did not take the soundings thereof.

Q.—Was the beach abreast of the bank always free of surf?

A.—From information obtained, I believe it was.

Cochin,
27th August 1861.

Mr. D. Aranja is now pensioned, and held the office of Fiscal in this town formerly.

(Sd.) JOHN CASTOR,
Master Attendant.

The deposition of Warrid Antha, inhabitant of Vypeen.

I am a Ship Carpenter by profession, and had been often employed by the late Mr. Poney Gueizelar, Ship-builder of this Port. I am now sixty-six years of age , and have a perfect recollection of having been engaged with several other workmen about twenty-eight years ago, by the late Mr. Gueizelar, to proceed to the mud-flat off Narrakal, for the repair of an Arab ship of about 500 tons, which took refuge there owing to the rough state of the sea at Cochin. It was then about the end of May or beginning of June. While we worked on board, we experienced no inconvenience from the rolling or pitching of the vessel, as the sea was perfectly smooth. One of the workmen who accompanied me on the occasion referred to, is now living at Cochin· I frequently visited the place since that period, and always found the sea calm, and fishermen carried on their occupation there throughout the year. I am prepared, if needed, to affirm this statement upon oath.

His + mark
WARRID ANTHA

Cochin,
4th September 1861.

Before me,
(Sd.) JOHN CASTOR,
Master Attendant.

The deposition of Sheram Ally, Syrang of the Brig "Mooydeen Bux" of 154 tons, belonging to the Port of Cochin.

I am a Native of this coast, and have been sailing out of this Port in different capacities for twenty years; and for the

last eight, I have been in command of the "Mooydeen Bux'. I have known the mud bank off Narrakal for many years back, but particularly noticed it within the last ten years. The sea never breaks on the beach, and I have known vessels in stress of weather frequently resorting to Narrakal, where they lay perfectly still. Within my experience, I have found the sea, comparatively smooth, in seven fathoms; and from this depth, as the shore is neared, the stillness becomes greater. The advantage of the place is commonly known to coasting vessels.

(Sd.) SHERAM ALLY,

Syrang.

Cochin,

6th November 1861.

Before me,

(Sd.) JOHN CASTOR.

The deposition of Dervish Hadjee, Agent of His Highness the Imaum of Muscat, residing at Cochin.

I have been a resident of Cochin for upwards of thirty years. I have known the mud bank off Narrakal resorted to by ships in heavy weather. Thirty years ago, the ship Hamee Shaw, belonging to the Imaum of Muscat, arrived at Cochin during the south-west monsoon, disabled and owing to the heavy sea, she could hold no communication with the shore, but proceeded to Narrakal, to have her repairs effected, which was done under the supervision of the late Mr. Poney Guizelar, Ship-builder of Cochin. There was no sea at Narrakal at the time; and the workmen employed on the repairs had no difficulty whatever in going off to, and coming from the ship.

Five years later, another vessel of the Imaum arrived at Cochin, with the loss of her rudder, during the monsoon, and she also, being unable to remain in these roads, proceeded to Narrakal and refitted. The safety of Narrakal as a port, is generally known among the Native community of this Port, and coasting craft frequently resort to the place in bad weather.

(Sd.) DERVISH HADJEE.

Cochin,

6th November 1861.

This deponent is personally known to me, and is a very respectable person.

(Signed) JOHN CASTOR.

The deposition of Caimult Anday, inhabitant of Cochin.

I am a Ship Carpenter by profession, and had been often employed by the late Mr. Poney Gueizelar, Ship-builder of this port. I am now sixty-three years of age, and have a perfect recollection of having been engaged* by the late Mr. Gueizelar, to proceed to the mudflat off Narrakal, for the repair of an Arab vessel of about 500 tons, which took refuge there owing to the rough state of the sea at Cochin. It was then about the end of May or beginning of June. While we worked on board, we felt no inconvenience from the rolling of the vessel, as the sea was perfectly smooth. I often visited the place subsequently, and always found the sea calm. The fishermen carried on their occupation there throughout the year.

*About 28 years ago.

I am prepared if required to affirm this statement upon oath.

Taken at my Office.

Cochin, 6th November 1861. (Signed) JOHN CASTOR.

The deposition of Mr. Cornelius John Gueizelar, Master Ship-builder in the Port of Cochin.

About the year 1830, I was serving my time under my late father, Mr. Poney Gueizelar, who was Master Ship-builder of this Port. In June or July, an Arab vessel of about 500 or 600 tons arrived at Cochin from Muscat, but unable to remain in these roads, owing to the state of the sea, she proceeded to Narrakal, and underwent some repairs. My father proceeded to the vessel and contracted for the repairs, and supplied carpenters from Cochin. The vessel remained at Narrakal for a period of two months, and went on to Calcutta. I have frequently been at Narrakal, and always found the sea smooth and without surf.

On another occasion, about fifteen years ago, in the month of August, a vessel arrived in these roads, with the loss of her

rudder, but owing to the heavy sea, proceeded on close to Narrakal, and anchored there. I went on board while she was at anchor, and undertook the work. The vessel lay in smooth water at the time. She afterwards came to Cochin when the weather moderated.

(Signed) C. J. GUEIZELAR,

Cochin, 16th November 1861. Master Ship-Builder.

Extracts from the Master Attendant's Journal of Narrakal with reference to the condition of the sea on the mud bank.

Finding the wind and sea increase on the afternoon of the 7th, I resolved to visit Narrakal on the following morning, 8th August 1861.

8th August 1861.—Visited Narrakal at 10 a. m.. Weather cloudy, with light winds, and occasional squalls. To ascertain the depths from various distances off shore, went prepared with a line of 712 yards long. Engaged three small canoes, and started from the margin of the water in a direction at right angles, or W. S. W. of the coast. First distance, in a straight line of 640 yards, depth 11 feet, bottom very soft, water perfectly smooth. Second distance from the termination of the first, in a straight line of 640 yards, depth 15 feet, bottom very soft, water perfectly smooth. Third distance from the termination of the second, in a straight line of 640 yards, depth 20 feet, bottom very scft, a small bubble of a sea. Fourth distance, from the termination of the third, in a straight line of 640 yards, depth 24 feet, bottom soft, a little swell.

I must here observe, that these soundings and distances were conducted on a bearing of E. N. E. of a flag planted on the beach abreast of Narrakal; on this line, and at the distance of 2,560 yards, it takes you off the smooth water, and you are met by the swell, on the confines of the mud-flat. From this limit I pulled away in a N. W. direction to five fathoms, with the village of Narrakal bearing E. b. S. to E. S. E. ½ S.; found the sea in this locality perfectly smooth, bottom of a more consistent nature, and the sea and swell to the north and south, appearing as they rise, like sandbanks at a distance. I was in a canoe of

25 feet long, two feet six inches wide, and 22 inches deep, and wrote my notes on my knee with little or no inconvenience. Many fishing boats were plying their daily occupation; and the beach was without a ripple. In four fathoms Cruz Milagre well open.

Before leaving Cochin I noticed that the bar was impassable, and a tolerable high sea prevailing on the coast to the north and south.

Remarks—Saturday, the 17th August 1861.

Visited Narrakal. Weather squally, and blowing fresh from the westward, with a tolerable heavy sea on the coast, to the north and south. Planted a flag one-quarter of a mile to the north of the village, and ascertained the depths as follows. Pursued the same method as adopted on the 8th instant.

First distance in a straight line of 650 yards, flag E. N. E., depth 8 feet 6 inches, sea perfectly smooth, bottom very soft. Second distance, 650 yards, same bearings, depth 13 feet 6 inches, bottom very soft, water very smooth. Third distance, 620 yards, 16 feet, bottom very soft, a small bubble of a sea. Pulled out to four fathoms, found a little swell, which would never be felt or remarked in a small vessel. Seeing a very heavy squall rising to the westward, and the canoes employed on this occasion being very small, pulled in shore. I find to the north of Narrakal the shoal water extends further out. The beach perfectly smooth, without a ripple.

Monday, the 19th August 1861.

The wind being strong yesterday (Sunday) with unsettled weather, and violent squalls, and a fresh breeze still prevailing, I proceeded to Narrakal and embarked in a small canoe at 1-30 p. m. and pulled out to 3½ fathoms and anchored. Wind west, bottom very soft, sea smooth. Narrakal bearing E. b. S.—Cruz Milagre, S. E. Started from this point and pulled out to four fathoms and anchored, bottom soft, Narrakal bearing E. b. S. to E. b. S. ¼ S. Cruz Milagre, well open, S. E. Pulled out to 4½ fathoms, Narrakal E. b. S. Cruz Milagre, S. E. ½ E. Coorpally high tree, N. N. E. ½ E., bottom somewhat sticky, and appears good holding ground. Paid particular attention to the state of

the sea. From 3 to 4½ fathoms, there was a little swell, but in no wise to disturb a small vessel at anchor, and as a proof of this, I may mention that the canoe I was in, remained at anchor with eight men in her, and I wrote my notes, and took my bearings without any inconvenience. There was as much sea in four to five fathoms as there would be in Madras roads, with a light sea breeze in the month of March in fine weather. The sea encircling the mud bank, and to the north and south was high; but further on to the W. N. W. it appeared smooth. I did not wish to venture further out, as a heavy squall was rising to the westward, and the canoe I was in, small. Found the beach without a ripple. Narrakal E. b. S. ¼ S to E. S. E. appears a good bearing.

Tuesday, the 20th August 1861.

The weather being very unsettled and blowing strong at intervals in squalls, and a heavy sea prevailing on the Cochin bar, I proceeded to Narrakal; but, before I reached there, the wind died away. I pulled off in a fishing canoe, and went into four fathoms; found a little swell in this depth, but nothing to disturb shipping operations, had ships been lying there. The beach perfectly smooth, and without ripple. This smoothness extended to some distance from the land.

Thursday, the 22nd August 1861.

The weather being very monsoonish, and blowing strong at intervals, during the night of the 21st, and a very high sea prevailing on the coast for these last two days, I visited Narrakal. On arriving at the village, found the margin of the sea without a ripple. Engaged a canoe and pulled out to one quarter less five fathoms and anchored. There were a great many fishing boats in this depth pursuing their occupation. I found a gentle swell, as is often noticed in a calm out in the open ocean, occasionally lifting the canoe, but beyond this the boat scarcely moved. The absence of all crested waves was very remarkable, the sea to the north and south was clearly visible and breaking with great force, and its roar was distinctly heard. It may be only fancy, but I cannot refrain from recording, that the more turbulent the sea rages on the adjacent coast, the greater is the stillness which appears to prevail on this bank. I shall carefully watch whether this is a prevailing feature of this locality. Pulled out to five fathoms,

found the sea in the same state, now and then a little swell. The wind was very light at the time. Narrakal E. b. S. ½ S. to E. S. E. Cruz Milagre S. E. ½ E. Coorpally high tree N. E. ¼ E. to N. E. ½ E. bottom sticky and soft. In eighteen to sixteen feet the sea resembled a tank or pond in its stillness. Had there been any ships in the roads of Cochin, no communication could have been maintained with them from the tremendous sea on the bar.

(True copy)

(Signed) JOHN CASTOR,

Master Attendant.

N. B.—Cruz Milagre, or the "Marvellous Cross", takes its name from a Roman Catholic Church which once stood on the beach, about a mile and a half from Cochin. The church was destroyed by the ravages of the sea. The gap formed in the belt of cocoanut trees which fringes this coast, is still called, "the opening of Cruz Milagre".

(Signed) JOHN CASTOR,

Master Attendant.

TABULAR STATEMENT OF DEPTHS WITH THEIR RESPECTIVE DISTANCES FROM SHORE.

Date	Abreast of Narrakal		Nature of the bottom	Date	Quarter of a mile to the north of Narrakal		Nature of the bottom	Date	Half to three quarters of a mile north of Narrakal		Nature of the bottom
	Distance off shore	Depth			Distance off shore	Depth			Distance off shore	Depth	
	Yards	Feet			Yards	Feet			Yards	Feet	
1861 August 8th	640	11	Very soft	1861 August 17th	650	8	Very soft	1861 November 13th	330	2½	Very soft
" "	1,280	15	do ..	" "	1,300	13½	do ...	" "	660	4½	do ...
" "	1,920	20	do ..	" "	1,920	16	do ..	" "	990	9	do ..
" "	2,560	24	Soft ..	" "				" "	1,320	12	do ...
								" "	1,650	12	do ..
								" "	1,980	14	do ..
								" "	2,310	16¾	do ...
								" "	2,640	18	do ..
								" "	2,970	19	do ..
								" "	3,300	21	do ...
								" "	3,630	22	do ...
								" "	4,000	24	do ...

Independent of the results herein indicated, other soundings were carefully taken on the bank abreast of Narrakal

(Signed) JOHN CASTOR.

The soundings were conducted by the aid of three boats, two for laying out the line from point to point, one of which alternately remaining at anchor, till the other exhausted the line, and anchored. I was in the third boat, following the operation and sounding at the termination of each length. The line was previously measured, and strict allowance was made for the bight or deflection caused by the tide. This method of measuring in fast pulling, boats, could not involve any great practical eror.

(Signed) JOHN CASTOR,

From Francis N. Maltby, Esq., Resident of Travancore and Cochin, to T. Pycroft, Esq., Chief Secretary to Government, Fort Saint George, dated 27th November 1861, No. 58.

I have the honour to report for the information of His Excellency the Governor in Council, that I yesterday visited, in company with the Diwan of Cochin, the shore of the sea at Narrakal in the neighbourhood of the mud bank which has lately attracted much attention.

2. Captain Castor, the Master Attendant of Cochin, met me on the spot.

3. The Government have received full reports on this subject, so that I need not recapitulate the information which has been collected by others, and submitted to them. I shall only state that at the present time the shore is so entirely free from surf that canoes were run ashore with their sails set. Both the Diwan and Captain Castor assured me that during the south-west monsoon the sea had not even the slight ripple which I saw yesterday.

4. Of the value of the bank as a roadstead, I think there can be no doubt, but it has undergone considerable changes, and it will be necessary to watch the movement of the bank for some time, before it can be safe to construct any expensive or permanent works.

5. The course which I have suggested to the Government of His Highness the Rajah of Cochin is, that a timber scaffold be erected on the beach sufficiently conspicuous to guide the shipping to the bank. This should be about sixty to eighty feet in height, with a flagstaff on the top. It should be publicly notified that ships are allowed to land their cargo there, on giving in their manifests at the neighbouring port of Malipuram.

6. This, I think, is all that is desirable at present. The place is already convenient for trade, as the beach is only separated from the backwater by a bank of a quarter of a mile over which there is a road.

7. Should the place become the resort of shipping, it would be easy to construct a small jetty on screw-piles, and to bring a

canal from the backwater to a Custom House close to the beach, as at Alleppey.

8. As it is desirable that any arrangements made in His Highness the Raja's territories should be made in consort with the British Government, I have the honour to request that I may be informed, whether the above views meet with the approval of His Excellency the Governor in Council. Should they do so, Captain Castor's assistance in selecting the site for the structure, and notifying the bearings of the bank, will be valuable.

Order thereon, 20th December 1861, No. 430.

Ordered accordingly that Proceedings 26th July last, No. 242, and the papers received with the first of the above letters, be published in the "Fort Saint George Gazette". The Superintendent of Marine will be furnished from the Gazette Press with as many copies as he may require for distribution as he proposes. Copies will also be sent to the Agent to the P. and O. Company.

2. The Government approve the proposal in Mr. F. Maltby's letter as to the works to be immediately constructed at Narrakal. The Superintendent of Marine will instruct the Master Attendant at Cochin to afford the required assistance.

3. Captain Castor will also be ordered to draw up directions for anchoring. His Excellency in Council desires that the mud bank be further watched during the next south-west monsoon and its condition during heavy weather reported.

(True extract)

(Signed) T. PYCROFT,

Chief Secretary.

To

The Superintendent of Marine.

" Resident, Travancore and Cochin (with a copy of the entire papers).

" Collector of Malabar do

" Agent, P. and O. S. N. Company do

" Superintendent, Gazette Press.

Proceedings of the Madras Government, Public Works Department, 11th July 1865.

No. 253.—Read the following letter from J. J. Franklin, Esq., Superintendent of Marine, to Colonel, C. A. Orr., R. E., Secretary to Government, Public Works Department, dated Madras, 29th June 1865, No. 2438.

Sir,

I have the honour to forward a Chart of the Narrakal anchorage executed by Captain Castor; the Master Attendant at Cochin, under the authority conveyed in Proceedings of Government of the 27th February last, No. 552. A brief Memorandum accompanies the Chart.

2. The work has been accomplished by Captain Castor in a very creditable manner, and I have no doubt is to be perfectly relied on. If the Public Works Department could lithograph the Chart on a reduced scale at a moderate charge I would recommend that 200 copies be struck off and distributed for sale at Bombay and Calcutta, as well as in this Presidency, at a price that should cover the expense.

3. I likewise forward a bill of the expenses incurred during the examination, amounting to Rupees 69—12—9, and solicit sanction thereon.

Brief Remarks on the Anchorage of Narrakal, with reference to the Chart recently sketched.

The Chart was framed entirely from personal observation.

2. The line which indicates the extreme limit of the influence of the bank may not be laid down with strict critical accuracy, for the difficulty of fixing the exact permanent limits of a phenomenon entirely governed by natural causes, and subject to the varying force of wind and weather, will be easily recognised. But having had opportunities of boarding steamers in the south-west monsoon, far beyond the influence of the bank, I have carefully observed when running into the anchorage, the depths at which the sea began to lessen, and this afforded me a practical guide in fixing the limit to the best of my judgment.

3. The space enclosed by the inner line within which a pondlike stillness prevails, is very remarkable, and is maintained in all weathers, excepting perhaps in a heavy gale. I have seen canoes which would barely carry four men, plying on this smooth sea during the height of the south-west monsoon. The surface only is ruffled during heavy winds.

4. Within the limits indicated in the Chart, * the beach is free from surf almost throughout the monsoon. Occasionally at high tides, a little surf prevails abreast of the flagstaff, but not to endanger landing; and only a few yards more to the north, the beach is entirely free from surf, and frequently without a ripple in the south-west monsoon, and this feature is maintained during the prevalence of the bad weather, and boats freely communicate from the shore to the shipping in all weathers and at all times. The beach is often seen without any surf much further to the south than is shown in the Chart.

*From A to B.

5. The anchorage as shown from 3 to 5 fathoms is comparatively smooth. The depth of a fathom makes a perceptible difference in the motion of a vessel riding at anchor. Vessels in 3 to 4 fathoms ride very easy; and from 4½ to 5 fathoms little or no sea is felt. On the 13th instant, I was called upon to survey the bark "Fatel Manan" of 560 tons, lying in 4½ fathoms at Narrakal. I scarcely felt the motion of the vessel while on board; and she was riding with only 35 fathoms chain out, with a fresh breeze and heavy squalls at times. This vessel was discharging a cargo of rice with every convenience.

6. It is worthy of observation that before the setting in of the south-west monsoon, when the sea around is as yet undisturbed, a little surf prevails at, and in the vicinity of Narrakal. but the beach about three quarters of a mile to the north of the flag-staff is in variably smooth whenever it came under my observation. It is only in heavy weather when Cochin is shut to the navigator that Narrakal is freely open to him; and it is only then that the contrast is best appreciated.

7. The nature of the bottom consists of very soft mud. The soundings were taken with great care, and to secure accuracy a plank of 10 inches square was screwed on to the

lower part of the lead, to prevent its sinking into the soft mud. Although the bottom is soft, no vessels have been known as yet to drag their anchors, when they ride with a sufficient scope of cable.

8. I have also traced a Chart (coloured) of the coast from Cochin to Narrakal, showing the gap near Vypeen with soundings, and the extent of coast the sea has abraded away within the last 15 years.

Cochin, 20th June 1865.

(Signed) J. CASTOR,
Master Attendant.

No. 254.—*Order thereon 11th July 1865, No. 1952.*

The survey of the anchorage off Narrakal seems to have been well executed by the Master Attendant of Cochin, and does credit to that Officer.

Civil works, No. 36.

2. Agreeably to the recommendation of the Superintendent of Marine, the Government direct that 200 copies of the Chart be lithographed upon the scale of 4 inches to a mile, and distributed for sale among the three Presidencies.

3. The bill submitted by Captain Castor for expenses connected with the survey, amounting to Rupees 69—12—9, is sanctioned.

(True Extract)

(Signed) CHARLES A. ORR,
Colonel, R. E.
Secretary to Government.

Note.—The following reports do not bear on the mud bank problem but are evidence as to the alternate erosion and accretion of the beach referred to in Chapter I. Much the same thing happened in 1925/6 but the beach is now (1938) well to seaward of the light-house. (R. C. B.)

Proceedings of the Madras Government, Marine Department, 16th November 1867.

Read the following papers:—

No. 45.—*From the Acting Superintendent of Marine, to the Acting Chief Secretary to Government, Fort Saint George; dated Madras, 23rd August 1867, No. 2895.*

I have the honour to forward, in original, a letter received from Captain Castor, Master Attendant at Cochin, reporting the

encroachment of the sea opposite the new Light-house in construction at that port, and to solicit that orders may be issued to the Superintending Engineer, 7th Division, to furnish a report on the subject as early as practicable.

From Captain J. Castor, Master Attendant, Cochin, to the Superintendent of Marine, Madras; dated Cochin, 20th August 1867, No. 156.

I have the honour to report, for your information, that the sea has encroached considerably on the beach abreast of the new Light-house, and at high water it washes the base of the ramparts on which the Light-house is being erected; and I apprehend danger to the new structure, should the sea advance any more in this direction.

2. I beg to recommend that some effectual measures be promptly adopted for the protection of the ramparts; for, should this work be shaken, it will carry the Light-house with it. Stone ballast thrown down towards the sea facing of the ramparts, would be the best protection that could be given, but I regret to state that no stone ballast is available just now.

3. When I left Cochin on privilege leave on the 2nd June there was a space of about 250 yards between the sea and the ramparts; it now breaks within ten yards of the ramparts,—this will show how considerably the beach has been abraded away.

Forwarded to the Public Works Department, in view to an early report on the subject being called for from the Superintending Engineer, 7th Division.

Fort Saint George, 26th August 1867.

(Signed) F. BRANDT,
Under Secretary to Government.

Referred to the Superintending Engineer of the 7th Division, for early report.

(Signed) C. A. ORR, Col., R. E.,
Secretary to Government, P. W. D.

28th August 1867.

No. 64.—*From Colonel G. W. Walker, R. E., Superintending Engineer, 7th Division, to the Secretary to Government, Public Works Department, Fort Saint George; dated Calicut, 21st September 1867, No. 105.*

I have the honour to report on the encroachments of the sea at Cochin, as ordered by your endorsement of 28th ultimo on the papers herewith returned.

2. As stated by the Master Attendant, some 250 yards of sand have been washed away, and the sea breaks at the foot of the old "Holland" Bastion, within which the Light-house has lately been erected. Nothing of the scarp wall facing the sea, but its foundation, having existed for years, the earth and sand with which the Bastion is filled in was in imminent danger of being washed out; which process, if long enough continued, would doubtless have brought down the Light-house. But the measure adopted by Captain Castor, of throwing down such ballast as he could procure from the river frontage and borrow from the merchants, has proved effectual in arresting the progress of destruction.

3. Acting on instructions which I sent immediately on receipt of your endorsement, Mr. Eppinger (who obligingly undertakes our work at this isolated station, on commission) threw out a couple of small groynes with blocks of laterite, procured from other portions of the old ramparts. But, after carefully watching the action of the sea for more than a week, including a period of spring tides, I am not encouraged to propose their extension, as there does not appear to be any current so near in shore as to be capable of being influenced by groynes of a moderate length. I propose rather to utilise the existing foundations of the old face of the rampart; and, by sheet piling in front to secure them, and heaping up ballast and other material behind them, to rely on the Bastion itself, so faced, as a groyne or bulwark against further encroachments on this side of Cochin. A section of three yards in height, with slope of 1½ to 1 in front, and 1 to 1 in rear, gives a base of 7½ yards along a frontage of 80 yards, and a cubic capacity of 900 yards; to which I add 75 cubic yards to be thrown down as a spur at the south angle, where the foundations of some outwork crop out of the sand, and 25 cubic

yards along an old teak palisading which similarly projects for a few yards at the northern angle.

4. I reckon on obtaining half the quantity of material required at a moderate rate, with the aid of the Master Attendant, who has offered his services in procuring and landing for us at his yard all ballast available from the shipping, and who will make over to us, if so authorised by Government, a number of unserviceable guns and large blocks of stone, scattered about the place, and under his charge as Conservator of the Port. Rough masses of laterite will also continue to be dug out from the old ramparts inland. For the rest, I must allow a much higher rate, in case the deliveries of ballast from the shipping prove too scanty or tardy to suit our purpose.

5. It will be as well to combine with this work, on the Cochin side of the harbour mouth, a few groynes on the other, or Vypeen side. I have had a survey of the coast line taken, including both localities, and showing the sites of the Lighthouse Bastion, and of the groynes I would now propose. They should be five in number, and aggregating 100 yards in length, divided into two short groynes of 10 yards, two of 20 yards and a central groyne of 40 yards long. In construction, they would resemble those alluded to in paragraph 7 of G. O., No. 257, of 29th January 1863, but filled in with ballast, instead of lighter material. In my opinion, the three similar groynes formerly erected, though filled in with cocoanut husks and such like rubbish, did good service, so long as they held together, and only required repair and maintenance to have been permanently useful; but they were out flanked by the sea, and not extended as required; their planking got loosened and stolen; their contents carried away by the waves; and eventually every constituent particle vanished. I would now throw them out by 10 yards at a time, only adding to the longer ones, as the sand silted up, and taking due care to maintain them; for which, and the rampart facing, a discretionary annual allowance of Rupees 500 might be made for a few years. The effect I anticipate from them would be simply to conserve the sea frontage of the British territory on the Vypeen side, now being washed away, together with that along the much more extensive strip of Cochin territory south of the Cruz Milagre Gap. That they would arrest

the damage anticipated by many from the extension of that Gap, I do not expect. But that opening belongs to the Cochin Government, which probably would not be willing that it should be closed; and though its extension should, in the course of years, sweep away the whole of Vypeen Island, I do not imagine that the harbour of Cochin would thereby be materially and permanently affected; and to close it, if permitted, might involve an outlay exceeding the value, not only of the British portion, but of the whole of the Island. All I would recommend is to have an annual survey of the Gap and Island made by the Marine Department, showing the changes from one November month to another.

List of papers enclosed.

1. Survey of the Coast of Cochin.
2. Plan and Section of the old Rampart at Cochin.
3. do do of groynes proposed to be constructed at Vypeen.
4. Estimate of Rupees 3000 for a sea wall at Cochin,
5. do of ,, 1500 for 5 groynes at Vypeen.

(Signed) G. W. WALKER, Col., R. E.
Superintending Engineer.

Transferred to the Marine Department, with the opinion of the undersigned, that the works proposed by Colonel Walker are feasible, and likely to have the intended effect of checking the encroachment of the sea at Cochin.

(Signed) C. A. ORR, Colonel, R E.,
7th October 1867. Secretary to Government, P. W. D.

Referred to the Acting Superintendent of Marine for his remarks.

Fort Saint George, (Signed) F. BRANDT,
29th October 1867. Under Secretary to Government.

No. 47.—*From the Superintendent of Marine, to the Chief Secretary to Government, Fort Saint George; dated Madras, 1st November 1867, No. 3580.*

In returning the accompanying papers, forwarded for remarks on the 29th ultimo, I have the honour to state that the plan

proposed by the Superintending Engineer of the 7th Division for checking the advance of the sea at Cochin, whereby the rampart, on which the light column is situated, was during the last south-west monsoon in imminent danger of being breached, appears to offer a fair prospect of effecting the object in view, and I recommend that the estimate of 3,000 Rupees be sanctioned, the expenditure being debited to the General Ports Fund.

2. The Master Attendant at Cochin, to whom much praise is due for the energetic manner in which he, on the danger first manifesting itself, filled up the breaches made by the sea with stone, has also submitted a plan which I forward, with extract from his letter on the subject. The main difference between this and that of Colonel Walker is that it substitutes groynes at each end of the rampart, in lieu of a compact sea wall. I prefer the latter, and should it hereafter be found that groynes are necessary they can be added.

3. Colonel Walker likewise proposes groynes on the Vypeen side for the preservation of the Coast, which has been in course of erosion for the last six or eight years. On this question, I will address Government at a later date.

Extract of letter from Captain J. Castor, Master Attendant at Cochin, to the Superintendent of Marine, Madras; dated Cochin, 25th October 1867, No. 201.

With a view that the authorities at a distance may be made acquainted with the nature of the locality which is now threatened by the advance of the sea, and be able to judge of the value of the remedies suggested for the protection of the Light-house and that part of the town, I have the honour to submit a sketch taken under my supervision, showing the encroachment of the sea, and the depths of water prevailing abreast of the rampart. These depths may be expected to decrease as the season advances.

2. The sketch, which is sufficiently accurate for all practical purposes, also indicates the position where I recommend the construction of two groynes, each of 70 feet long, and about two or three feet above high water mark, which, in my opinion, is the only remedy that offers any certain promise of success and security. I have confined myself to what is necessary for the protection of the Light-house.

3. The loose revetment of stone formed round the base of the rampart, and which is still being proceeded with, has doubtless tended to the temporary safety of the place. This promises to be effectual, so long as no disturbing influence of an extraordinary character operates on the shore; but in a gale of wind, when the waters are heaped on the shore, I am of opinion that the sea would wash clean over the rampart, more especially if it occurred during the springs.

4. I am strengthened in this opinion by the fact that the southern sand, on which the water was very shallow, has been scoured away to a large extent during the last season, and the monsoon swell, which formerly exhausted itself on this foreshore rolls in with unchecked impetuosity, and breaks with great violence at the base of the rampart.

5. There is another danger which should not be overlooked even if the rampart stood as a breakwater. There is nothing to prevent the sea from encroaching and washing over the road, and turning the rampart from the southward, or carrying away the sand embankment between the Light-house and the cemetery. The only security against this is the formation of a permanent beach, which, as all experience shows, can be created only by groynes.

No. 48.—*From the Collector of Malabar, to the Chief Secretary to Government, Fort Saint George; dated Calicut, 8th November 1867 No. 131.*

The enclosed communication to your address has been sent to me for transmission by the Vice-President of the Cochin Municipal Commission, who observes that it is his firm conviction that, unless some vigorous and effectual measures are used at once, to stay the progress of the sea, serious and irreparable injury to the town and port will be the consequence.

2. I have sent a copy to the Superintending Engineer, who lately visited the Port of Cochin, and directed such steps to be taken as to him then appeared necessary.

From Messrs. Scott Brothers, and Co., and other inhabitants of Cochin, to the Chief Secretary to the Government, Fort Saint George; dated Cochin, 6th November 1867.

We, the undersigned inhabitants of British Cochin, who are deeply interested in the welfare of this port have the honour to bring to your notice the imminent danger to which our property and that of our fellow-townsmen in general is exposed by the ravages of the sea, and beg you will submit this communication to the Governor in Council.

2. Within the last few months, the sea has encroached more than 150 yards, washing away one public road, and threatening the existence of the newly erected Light-house.

3. The prompt energy displayed by Captain Castor, the Master Attendant of this Port, in throwing in a large quantity of stone ballast, and so forming an embankment to break the force of the sea on the old rampart on which the Light-house stands, has hitherto protected that building from destruction; but, on either side, the little beach still left is rapidly disappearing.

4. The efforts of the Public Works Department appear to us unintelligible. What has been done has proved utterly futile; piles and planking which have been placed one day have been removed the next, on it being found that they were working mischief, and increasing instead of diminishing the abrasion; and the small stones and old masonry which have been thrown down to form groynes have been swept away, and at the present time scarcely any of the large quantity of material used is visible.

5. Our object in writing is to respectfully urge on the consideration of Government the necessity for the adoption of some measures for arresting the progress of the sea more likely to be effectual than those already tried. We do not wish to thrust our opinion of what should be done on the attention of Government, but we think that two or three groynes, formed of blocks of stone of sufficient size to resist by their weight the force of the breakers, would tend to the formation of a permanent beach, and save us from the impending danger, which, to most of us, who have large interests at stake in the place, is of vital importance.

6. We may mention that the stones alluded to above are procurable in almost any quantity on the backwater.

No. 49.— *Order thereon, 16th November 1867, No. 289.*

The Governor-in-Council approves of the proposals made by the Superintending Engineer, 7th Division, for checking the advances of the sea at Cochin by the construction of a sea wall and by the adoption of the measures specified in his letter of the 21st September, at a cost not exceeding Rupees 3,000.

2. The amount now sanctioned will be debited to the General Ports Fund.

3. Much praise is due to Captain Castor, Master Attendant at Cochin, for the prompt and effectual measures adopted by him for arresting the encroachment of the sea in the vicinity of the Light-house rampart.

4. The Government will await the report promised by the Superintendent of Marine on Colonel Walker's proposals for constructing groynes for the preservation of the coast on the Vypeen side of the harbour.

(True extract)

(signed) R. S. ELLIS,
Chief Secretary.

CHAPTER IV

EXTRACTS FROM THE

Madras Journal of Literature and Science, Vol. VI, New Series
Vol. XXII, Old Series.

Pages 127 to 138.

Being the reports and proceedings of the Madras Government as to public works in Travancore, 1860.

CHAPTER IV.

PROCEEDINGS OF THE MADRAS GOVERNMENT.

Read the following letter from Francis N. Maltby, Esq., Resident of Travancore and Cochin, to T. Pycroft, Esq., Chief Secretary to Government, Fort Saint George, dated 26th June 1860, No. 38.

I have the honour to report, for the information of His Excellency the Governor in Council, that Mr. Collins, appointed Civil Engineer to the Rajahs of Travancore and Cochin, assumed his duties at Cochin on the 17th April last, and, after a short tour in the Cochin State, joined me at Trivandrum on the 16th ultimo.

2. As it is of much importance that the Madras Government should be kept fully informed of the progress of the Public Works of these States, I have the honour to lay before them, the following statement of the plans which will first occupy Mr. Collins' attention.

3. I have first to allude to the works which Mr. Collins found already in progress at the Port of Alleppey, under the charge of Mr. Crawford, the Commercial Agent.

4. Alleppey is the commercial capital of the State of Travancore, and already possesses a very considerable trade. Though not enjoying the advantages of any land-locked harbour, it is still well suited to commerce. The town is situated on the sand-bank, which separates the large estuary of Cochin from the sea, and a Canal cut from the backwater through the heart of the town, conveys the produce of the interior to the doors of the Merchants' stores, and within a furlong of the sea.

5. But the principal advantage of the Port of Alleppey is its remarkable mudbank, which renders its open roadstead a safe harbour of refuge throughout the whole of the south-west monsoon. However this remarkable phenomenon may be accounted for, it is a fact that in the stormiest weather of the south-west monsoon within the influence of this bank, there is stilll water

at sea, and so little surf on shore, that boats can land at all times, and the landing and shipping of cargo can be carried on throughout the monsoon.

6. The general theory is that the soft, almost fluid, mud yields to the pressure of the great waves and prevents their rising above the ocean level.

7. However this may be, this provision of Providence affords to this Coast a safe harbour of refuge, and it is only to be regretted that it is so little known.

8. I am informed that in a book, nearly two hundred years old, the voyages of Captain Cope, Alleppey, is alluded to in a way which proves that its advantages were then known and appreciated. It is spoken of as "mud bay", and described as one of the most extraordinary harbours in the world. But subsequently, probably in consequence of the disturbed state of Travancore, the trade of Alleppey declined, and the Canal dug by a former Sovereign of the country, was, at the beginning of this century almost entirely choked up, (see Colonel John Munro's early reports) and the advantages of "mud bay" have been greatly lost sight of.

9. But within the last few years the trade has been considerable, and the annexed list of vessels which in the last 5 years have taken out Port clearances in the months of June, July, August and September (the 4 months during which the coasting trade is in abeyance at other Ports of the coast) proves that the advantages of the Port are again beginning to be appreciated.

10. But in order that the shipping may derive full advantage from the refuge afforded by the bank, a conspicuous Lighthouse and a light of sufficient power to penetrate the haze of the monsoon are required. The present Flagstaff cannot in hazy weather be distinguished from the cocoanut trees, and the lantern exhibited upon it is of insufficient power; while vessels which fail to find the bank are on a dangerous lea shore.

11. Mr. Crawford, the Commercial Agent, has long urged the necessity of this work, and General Frederick Cotton, who lately visited the Port, was so much struck by its adaptation to what has been so long sought for, a harbour of refuge on the

Malabar coast, that he strongly recommended that no time should be lost in building a Light-house.

12. This highly important work has been sanctioned by His Highness the Rajah of Travancore, and the foundation is already laid. The Canals are also being extended; and a Railway is being laid down from the Canal to the sea side. This will, if practicable be carried on a small jetty into the sea, but there is some doubt whether the muddy bottom admits of this. Some peculiar action is going on under the sea. At times huge cones of liquid mud are forced up in the sea near the shore, and this is accompanied generally by a subsidence of the sand near the waters edge to a dimension equal to the bubble or cone of mud. It is therefore very doubtful whether a jetty could be laid without the piles being undermined by these changes in the mud-bed.

13. These works will however make the port of Alleppey a convenient shipping port in immediate connexion with the inland water communication, which forms so important a feature of this country.

14. The commencement of these works is due to the energy of Mr. Crawford; they will now be carried on under his superintendence, guided by the professional skill of Mr. Collins.

15. One of the first works to which Mr. Collins' attention has been directed is the construction of a Bridge over the Ponany river, in order to bring the Northern portion of the State of Cochin into connexion with the Madras Railway. The Rajah of Cochin had expressed to me his readiness to sanction the expense necessary for this Bridge, and for a road to Trichur, an important trading place at the head of the navigation of the Trichur Lake. Mr. Collins has fixed upon a site for the Bridge close to the Railway Station, and has found the intervening country from the river to Trichur (20 miles in length) very favourable for a road or Railway. Plans will be prepared for a Bridge on the Railway level, and a survey of the country is already in progress with a view to constructing a road on such a plan, that all the drains and culverts shall be suited to a Railway, should one eventually be laid down.

16. By this arrangement, a traveller from Madras by the Railway will only have to drive over these 20 miles to embark on

the inland navigation, which extends, with one interruption only, to Trivandrum, touching at the important stations of Cochin, Alleppey and Quilon.

17. To overcome the one interruption alluded to, and to extend the communication from Trivandrum to Cape Comorin, are the works which are now occupying Mr. Collins' attention; and carefully prepared plans and sections executed in 1828 by Lieutenant (now Colonel) Green, when Colonel Morison was Resident, afford the necessary means of studying the subject.

18. The interruption at Vurkullay is caused by a laterite hill having a base of 4 miles, and rising to 180 feet. Of the base, three miles, one and a half on each side, consist of terraced rice fields rising from the backwater to an elevation of 93¼ feet.

19. I believe that the measure adopted will be to shorten the interruption by a Canal of one mile on each side, and to reduce the hill by a cutting of 80 feet over the intervening space of 2 miles, a Railway will be laid having a gradient of 30 yards to the mile or 1·58. Over such a Railway, on suitable trucks, the Canoes used in this country with their cargoes can be easily drawn.

20. The advantage of this plan is, that it is so much work done towards a thorough Canal, and there is no doubt of its being even in this imperfect state highly remunerative. The contractor now pays 10,000 Rupees a year for the right of conveying goods from one backwater to the other, and with such increased convenience the trade will largely increase. Trucks pushed by coolies up the incline, and going down by their own weight will rather expedite than retard the traveller by the backwater.

21. It is probable that eventually a tunnel will be found more practicable than an open cutting.

22. The construction of a canal from Cape Comorin to Trivandrum has just been commenced by His Highness the Rajah, and, in honour of the Queen of England, it will be called the "Victoria Canal". It can be brought at a moderate cost to within seven miles of Trivandrum, where a series of granite rocks and laterite hills offer serious obstruction. Over this portion, some such expedient as that described above must be

resorted to; but if the rice and salt of the south are brought to within seven miles of Trivandrum and the whole line of water communication from Cape Comorin to the Railway is complete, with the exception of two short porterages, the trade will probably be developed to a degree which will warrant the expensive works necessary to render the water communication complete.

23. To open out the interior of the country, roads striking off from the backwater are required. Three of these have been planned; one from Trivandrum to a Sanatarium on the mountains due east and so to Papanasam; one from Kottayam over the mountains to Dindigul, and one from the Cochin backwater to join the the road under construction from Pollachi to the Anamallay forests. Of these the two former have just been commenced.

24. A thorough repair of the southern road from Trivandrum to Tinnevelly is also about to be commenced.

25. Two other subjects connected with the backwater are also engaging Mr. Collins' attention.

26. The first is a series of columns, with lights to guide the craft to the entrances of the rivers and Canals. The want of such assistance is much felt, and His Highness being desirous of erecting a monument within his territories to the memory of the late General John Munro, has resolved to dedicate these columns and lights to that purpose.

27. The second is the improvement of the drainage of the land in the Trichur Lake by substituting for the desultory and uncombined efforts of the natives, a series of drains scientifically laid out; and for the wheels worked by human power the mechanical application of wind or steam. At present the valuable cultivation of the Trichur basin is periodically destroyed by floods, whereas there is no doubt that the application of science will not only render the present lands secure, but also recover a considerable extent of additional land.

28. To this important subject Mr. Collins brings a valuable fund of Engineering knowledge.

29. In laying before the Government of Madras this sketch of the principal works required for these Territories, and which I hope will be actively carried on, I need hardly call their

special attention to the fact, that the bringing of the Madras Railway to the head of the Trichur Lake will enable the important harbour of Cochin to compete for the trade of Coimbatore and the Nilgiris in Cotton and Coffee, and I believe that its great natural advantages will become very conspicuous. The port of Cochin in the fair season and Alleppey in the south-west monsoon, when connected by an efficient inland navigation, connected again with the Madras Railway, possess advantages which I believe no artificial means can give to any other ports on the coast, and it is for this reason that I have thought it desirable to lay the above summary before the Government, at a time when the shortening of the communication between England and Calcutta by a route across this Presidency, is under consideration.

P. S.—Since the above letter was drafted, I have received a very interesting communication from Mr. Crawford on the subject of the Alleppey backwater, which I have the honour of annexing. A copy will be sent to Mr. Collins, who will I am sure afford Mr. Crawford his assistance, in explaining the remarkable phenomena which Mr. Crawford describes.

No. 201, dated the 20th instant.

Extract from Hamilton's account of the East Indies in Pinkerton's collection of voyages and travels (1678 to 1723).

Mud-bay is a place, that ,I believe, few can parallel in the world; it lies on the shore of Saint Andrea, about half a league out in the sea, and is open to the wide ocean, and has neither Island nor bank to break off the force of the billows which come rolling with great violence on all other parts of the Coast in the south-west monsoon, but on the bank of mud, lose themselves in a moment, and ships lie on it, as secure as in the best harbour without motion or disturbance. It reaches about a mile long shore, and has shifted from the northward in 30 years about three miles.

A manuscript note has the following remark:— This singular accumulation of mud still exists and still affords the same convenience for anchorage in the worst weather. The present account was published in 1723 and now in 1825. The.

mud bank has shifted from Saint Andrea in N. Lat. 9°40' to Poonangonot in N. Lat. 9° 25' being 15 miles in 102 years.

The mud bank now (1860) is in Latitude 9° 28'30."

From Hugh Crawford, Esq., Commercial Agent at Alleppey, to Francis N. Maltby, Esq., British Resident of Travancore, Trivandrum, dated 20th June 1860, No. 201.

I have the honour to acknowledge your letter, No. 988 of the 16th instant and have in accordance with your directions affixed a note to each Chart of the Roads of Alleppey, that the soundings are in feet not fathoms.

Lieutenant Taylor attributes smoothness of the water to the soft mud at the bottom, which when "stirred up by a heavy swell from seaward the activity of the waves is so deadened as to render the shore line free from surf". I regret never having met Lieutenant Taylor.

A number of years ago, I brought to the notice of General Cullen, that the perfect smoothness of the water in the roads and at the beach at Alleppey, was attributable, not to the softness of the mud at the bottom, so much as the fact of the existence of of a subterranean passage or stream, or a succession of them, which communicating with some of the rivers inland and back water, become more active after heavy rains, particularly at the commencement of the monsoon, than in the dry season, in carrying off the accumulating water, and with it vast quantities of soft mud. General Cullen the Resident sent a quantity of piping and boring apparatus in order to test the existence, or otherwise, of what I had urged. Accordingly, I sunk pipes about 700 yards east from the beach and at between 50 and 60 feet depth; and after going through a crust of Chocolate-coloured sand-stone, or a conglomerate mixture of that and lignite, the shafting ran suddenly down to 80 feet. Fortunately, it had been attached to a piece of chain or it would have been lost altogether. Several buckets from this depth were brought up which corresponded in every respect with that thrown up by the bubbles as they burst at the beach, which I shall here try to describe as accurately as I can. Due west of the Flagstaff and for several miles south,

but not north of that, the beach will after or during these rains, suddenly subside, leaving a long tract of fissure varying from 40 to 100 or 120 yards in length, the subsidence is not so quick at first, but when the cone of mud once gets above the water the fall is as much as 5 feet in some instances, when the cone bursts, throwing up immense quantities of soft soapy mud, and blue mud of considerable consistence in the form of boulders, with fresh water, debris of vegetable matter, decayed, and in some instances green and fresh. These bubbles are not confined to the seaboard, but are, I am inclined to think, both more active and numerous in the bed of the roads with the Flagstaff bearing from E. N. E. to the south, until it bears N. E. by N., or even south of that. About five years ago for about 4 miles down the coast and from the beach out to sea for a mile and a half, the sea was nothing but *liquid* mud, the fish died and as these cones reared their heads above the surrounding mud they would occasionally turn over a dead Porpoise* and numerous other fish; the boatmen had considerable difficulty in urging their canoes through this to get outside of it. The beach and roads presented then a singular appearance, nothing to be seen but those miniature volcanoes, some silent, others active, perfect stillness of all around the ships in the roads as if in some dock, with a heavy sea breaking in 7 fathoms outside.

*Porpoises are very numerous in the back-water

F. N. M

There are numerous deep holes, some of them I measured in 1852, one in particular just at the end of this canal had as much as 60 feet in depth, these holes may, or may not communicate directly with the roads; but I think it will be found that the principal source of active communication, is more inland, and the backwater perhaps only an auxiliary. About 3 miles above Chenganoor in the river of that name, there is one or two deep "Linus" which I only had an opportunity of visiting twice; the first time, I had not the means of ascertaining the depth, the next I lost both lead and line.

The depth of this passage is not so great as you approach the beach as noticed above, for, while extending the Canal from the Timber Depot in March last, about 200 yards from the beach at 12 feet, we suddenly and unexpectedly broke through the sub-

stratum when a column, fresh water, mud and vegetable debris and about 9 inches in diameter, spouted up, which, when left alone, gradually subsided as the upper stratum of sand filled in round the column of the spring.

I submit the above information as I feel that it will be interesting both to yourself and Government, to pursue the investigation of this subject more efficiently. I have omitted to state one important particular, that is, should *no* rain fall, as has been the case this year, the sea in the roads and at the beach is not *nearly* so smooth; up to this time we have had none of the mud cones bursting at the beach, neither in the roads, as the waves tumble in perfectly clear; there was a heavy surf from the 26th ultimo to 9th instant, but never in any instance for these last 11 years has the rain held off so long as in this, and the roads and beach have always by the end of May been perfectly smooth. To illustrate the perfect smoothness of the roads after the monsoon has fairly set in, a ludicrous event which occurred two years ago, will suffice. During a heavy westerly gale of wind in May 1858, a ship had to call at Alleppey for Pepper bound to London, the Captain who had been frequently here before, sighted the light at midnight, and ran from the heavy sea into the smooth water of the road, the small sail they had set was soon stowed and the anchor got ready, the Leadsman being told to report when he got into 4½ fathoms. Time elapsed, and considering the strong gale that was then blowing right on to the shore, the ship should have been in that water long before, but to every enquiry of the Captain "6 fathoms" was reported, until he took the lead line in his own hand, and discovered for the first time, that the ship was aground! the anchor was let go, and notwithstanding the distance she had over-run she swang at once to the wind, and remained all night until the next afternoon when the wind drawing more to the northward she made sail and stood out to the proper anchorage, remaining there, as she did when aground, still as in the London docks.

The fall of rain up to this time is only 7 9/10th inches since April and from the 1st of January 13 inches only.

Order thereon 14th July 1860, No. 426.

1. The Resident of Travancore and Cochin reports that Mr. Collins, appointed Civil Engineer to Their Highnesses the

Rajahs of the two States, assumed charge of his duties on the 17th April last. Mr. F. Maltby gives a sketch of the works which are under execution or in contemplation under Mr. Collin's supervision.

2. These are:—

1st.—The construction of a Light House at the port of Alleppey, the extension of the Canal from the backwater to the Town, and the laying down of a line of Railway from the Canal to the Sea-side. These works in progress. Mr. Maltby adverts to the peculiar circumstances of the Port of Alleppey which render it a perfectly safe harbour throughout the south-west monsoon, and he forwards an interesting letter upon the subject from Mr. Crawford the Commercial Agent to His Highness the Rajah.

2nd—The construction of a Bridge over the Ponany River in order to bring the Northern portion of the State of Cochin into connection with the Madras Railway, and of a road thence to Trichur an important trading place at the head of the navigation of the Trichur Lake. His Highness the Rajah of Cochin has expressed his readiness to sanction the expense of both these works. The site of the Bridge, close to the Railway Station, has been fixed on. The intervening country between the River and Trichur (20 miles) has been found to be very favourable to a road or Railway, a survey is already in progress with a view to constructing a road on such a plan, that all the drains and culverts shall be suited to a Railway, should one eventually be laid down.

3rd.—The construction of a Canal, to be called the Victoria Canal, from Cape Comorin to within 7 miles of Trivandrum from which there will be a portage to Trivandrum. This canal has been commenced by His Highness the Rajah.

3. It is further in contemplation to overcome, as far as possible, the only interruption in the inland navigation between Trivandrum and Trichur, via Quilon, Alleppey and Cochin, or that at the Vurkullay hill by extending the present Canals for one mile on each side of it, cutting down the hill to the extent of 80 feet for the intervening two miles and having a Railway for that distance. Over such a Railway, on suitable tracks, the Canoes used in this country with their cargoes can be easily drawn, a similar expedient will probably be adopted for the

portage from Trivandrum to the head of the Victoria Canal above alluded to.

4. Roads striking off from the backwater to open out the interior of the country.

1st. From Trivandrum to the mountains due east and so to Papanasam.

2nd.—A road from Kottayam over the mountains to Dindigul. These two have just been commenced.

3rd.—A road from the Cochin backwater to join that under construction from Pollachi to the Anamally forests.

4th.—The southern road, from Trivandrum to Tinnevelly is also about to be thoroughly repaired.

5. The erection of a series of columns with lights to guide the craft to the entrances of the Rivers and Canals. The want of such assistance is much felt and His Highness being desirous of erecting a monument within His Territories to the memory of the late General John Munro has resolved to dedicate these columns and lights to that purpose.

6. The improvement of the drainage of the land in the Trichur Lake. These two last subjects are engaging Mr. Collins' attention.

3. His Excellency the Governor in Council, has received with high gratification this list of works of public utility undertaken or projected by Their Highnesse the Rajahs of Travancore and Cochin. The energetic prosecution of these works cannot but redound greatly to the honour of those Princes and will be of the utmost benefit to their subjects. The Resident will communicate these sentiments to the Rajahs. Mr. Maltby's report will also be forwarded to the Right Honourable, the Secretary of State for India, whose attention will be called to the laudable exertions being made by Their Highnesses for the improvement of their Territories.

4. A copy of Mr. Maltby's report and of its enclosure, Mr. Crawford's letter on the Port of Alleppey, will be furnished to the Madras Literary Society.

(True Extract)

T. PYCROFT,
Chief Secretary.

CHAPTER V

EXTRACTS FROM THE

Records of the Geological Survey of India,

Vol. XVII, Part I, 1884.

Pages 14 to 27.

Considerations on the smooth-water anchorages, or Mud Banks of Narakkal and Alleppey on the Travancore Coast.

By W. KING, B. A., D. Sc., Deputy Superintendent, Geological Survey of India (with a map).

(Written after a visit in 1881).

CHAPTER V.

From time immemorial two anchorages on the west coast of Southern India have been known to mariners as presenting the marvellous feature of being perfectly quiet and smooth, while the sea outside may be tumbling in before the gales of the south-west monsoon. The bottom, or ground, of these anchorages is also peculiar in being a very fine, soft, unctuous mud, which has over and over again been supposed to act as a barrier against which the force of the waves was expended.

In these quiet roads, ships are not only able to ride safely, but, so it is said, can sometimes take in water alongside, the sea beneath them being so diluted with fresh water from inland sources at this particular season. Not only is there this wonderful quietness of the sea; but at times on one of the banks the smooth surface may be broken by burstings up, or huge bubbles—" cones " as they have been called—of water or mud from the sea bed, and even roots and trunks are reported to have floated up with these ebullitions. Yet, again, the banks of mud are not fixed in position, but move along the coast within ranges of some miles in extent; or one of them may remain comparatively stationary, while the other may move; and these movements do not take place year by year as having a relation to the monsoon periods, but continue over many years.

Unfortunately no continued series of systematic observations has ever been made with reference to these phenomena, so that no satisfactory conclusions could be formed as to their origin or causes. From time to time, however, observations have been made and suggestions offered, in explanation of them; some of which when looked into are very plausible, and may indeed be the right ones. There is no doubt, however, that certain of these observations require corroboration; and with a view to this, the present paper—practically a compilation of previous knowledge—is now put forward.

Within the last few years, these banks have once more attracted attention: first, in a commission of enquiry into the harbours on the west coast in 1881, conducted by the then

Superintending Engineer (Colonel R. H. Sankey, R. E., C. B.) for Madras; and next by Mr. Logan, the Acting Resident of Travancore, in his Administration Report for 1881—82. The Harbour Commission was carried on early in the year, when the conditions of the weather were altogether unfavourable to any exhibition of the features of these anchorages, the sea being generally quite calm; but I was enabled then to obtain some specimens of the mud. An analysis of this showed its oily constitution, and thus some of the obscurity surrounding the action of the mud was cleared off. Subsequently Mr. Logan's evident great interest in the matter led to the writing of a paper by Mr. Rhode, the commercial Agent of Alleppey, which throws greater light on other features of the phenomena.

By all accounts there are other but quite insignificant patches of smooth water and mud bank at various points along the Travancore and Malabar coasts, but those best marked and most generally known, are near Cochin and Alleppey. There is no well-defined situation for either of these banks on account of their movements to the north or south. That near Cochin or the Narrakal bank may be said to lie between Cochin and the Cranganur river, 11¾ miles to the north; or the range over which it has been observed during the last 200 years is about 11¾ miles : it does not appear to have ever passed south of the northern spit of the opening of the great backwater at Cochin; and for many years its position has been about the middle of the range, between the Villages of Nairumbalum and Veearrakull (Narrakal). The other bank, 40 miles or so to the south of this, ranges from a mile or two north of Aulopolay (Alleppey) to Poracaud, a distance of 12 or 15 miles : it is now, and has been for several years, at the southern end of this range, and indeed goes often by the name of the Poracaud mud bank.

The term 'Mud Bay' has been applied by writers and explorers to both anchorages, though there is no bay feature about either of them now. An explanation of the use of the word 'bay' will be found in one of the extracts given further on.

The mud banks are situated close along the beach, but extend out to seaward for some miles, presenting a more or less semi-circular or flat crescentic convex edge to the long rollers

and tumbling waves of monsoony weather. Thus it is quite easy for boats or small canoes to put off from the shore.

Ordinarily during the non-prevalence of the monsoon, the sea is tolerably smooth, only rolling on the shore with more or less of a surf; and then these patches are only to be distinguished by the soundings of mud below them. Even when the monsoon bursts, it is said that they are not always distinguishable at once, but generally only after a few days or so when the whole sea line has been affected and the mud at these particular places stirred up. After this the muddy waters will calm down and so remain for the rest of the monsoon.

The mud itself is essentially characteristic, and as far as my limited experience goes of muds along this coast, unique. It is, when brought up, of a decided dark-green colour, slightly tinged with brown; exceedingly fine in texture, only slightly gritty at times from fragments of comminuted shells; very soft and oily feeling, altogether just like a very fine soft ointment or pomatum. After a time it dries and hardens, loses its oily feel, and becomes harsh like an ordinary mud. It is easily stirred up on the bank, being in its upper part of great liquidity, the lead or the boat pole sinking into it from 3 to 6 feet: below, it is more compact, and still deeper, forms a good holding ground for anchors. It has always been described as having a slimy or oily consistency, but that it actually contained oil has, I believe, only been surmised by a few observers; indeed, as will be seen further on, one scientific observer rather scouts the idea. There is no doubt, however, that it does contain oil in appreciable quantity, as ascertained by analyses of the specimens obtained in January 1881, and sent up then to the Survey laboratory in Calcutta.

The specimens sent up were as follows:—

1017. Mud, off the Cochin river mouth, 4 fathoms.

1018. Mud, from the Narrakal bank, 4 miles north, close in shore.

1020. Mud, from Narrakal Bank, off pier head, 2 fathoms.

1019. Mud, from Poracaud bank, 7 miles south of Alleppey, 1 mile from shore, 2½ fathoms.

1021. Mud, from Poracaud bank, 7 miles south of Alleppey, 2½ miles from shore, 4 fathoms.

My colleague, Mr. F. R. Mallet, who made the assays, writes:—

"All gave off, when subjected to distillation, some brownish-yellow oily matter lighter than water, and looking not unlike petroleum. No. 1019 gave off the largest quantity, 1017 nearly as much, 1021 a smaller amount, 1020 very little, and 1018 almost none: 1019 and 1021 were digested with ether, which extracted a small quantity of brownish-yellow greasy matter from them; the other samples were not tried in this way".

"The quantities of mud sent were too small to allow of the oily matter, (which in the case of 1019 only amounted to a drop or two), being subjected to examination."

A further point about the constitution of these muds is that they contain a considerable quantity of forameniferal and infusorial remains, which were described by the late Captain Jesse Mitchell, Superintendent of the Government Central Museum, Madras (*).

The foramenifera are referred to the genus Rotalina (D'Orbigny); and the Diatomaceae are summarised as containing in all 62 species belonging to 30 genera. He also says that the mud, first received, had a brown colour; but that a second supply, which was quite wet, had a somewhat greenish tinge, the colour depending on the quantity of water present. Some, which had been exposed for several days to the sun, became almost white.

I will now proceed to lay before the reader the further published information regarding these phenomena, and the theories as to their origin.

Alleppey-Poracaud bank.—The earliest account dates as far back as 1678 to 1723, in an extract from Hamilton's account of the East Indies in Pinkerton's Collection of Voyages and Travels, (†) which is given in the Administration Report for Travancore, 1860.

"Mud Bay is a place that, I believe, few can parallel in the world: it lies on the shore of St. Andrea, about half a league out

(*) Jour. Madras, Lit. and Sci., XXII, N. S 6., p. 264, *et seq.*

(†) See, XIII. Public Works of Travancore, Proceedings of the Madras Government, 1861, Published also in the Madras Jour. Lit., and Sci., XXII, N. S. 6., p. 127, *et seq.*

in the sea, and is open to the wide ocean, and has neither Island nor bank to break off the force of the billows which come rolling with great violence on all parts of the coast in the south-west monsoon, but on the bank of mud, lose themselves in a moment, and ships lie on it, as secure as in the best harbour without motion or disturbance. It reaches about a mile long shore, and has shifted from the northward in 30 years about three miles.

"A manuscript note has the following remark:—This singular accumulation of mud still exists, and still affords the same convenience for anchorage in the worst weather. The present account was published in 1723 and now in 1825, the mud bank has shifted from St. Andrea in N. Lat. 90° 40' to Poonaganot in N. Lat. 90° 25', being 15 miles in 102 years."

Mr. Maltby (then Resident) adds :—

The mud bank now (1860) is in latitude 90° 28' 30".

The next account I can find is of much later date, in "Notes of an excursion along the Travancore Backwater," by Captain Heber Drury, 45th N. I., dated 1858.

"Alleppey, (*) Aulopolay, or Alapushe, as it has been variously named, is the present commercial port of Travancore, and the principal depot for Salt, Cardamoms, Pepper, Teak-wood, and other products of the country. It is reached by a canal leading from the backwater nearly due west, the length being about 3 miles." * *

"Important as Alleppey is to the Travancore Government as a commercial depot, from the facility of an inland water communication, which enables the forest products to be brought to the very doors of the godowns established for their reception yet undoubtedly its greatest advantage as an emporium arises from the singular natural breakwater formed in the open roadstead, and which consists of a long and wide bank of mud, the effect of which is so completely to break the force of the houses (Sic), that large vessels in the stormiest weather can securely anchor in the open roads where the water is as calm as a mill-pond.

"It is this extraordinary deposit which has earned for Alleppey the name of "Mud bay". The origin of this deposition of

(*) Madras Jour., Lit. and Sci., XIX, N. S. 3, p. 217, *et seq.*

so large a quantity of mud in the open sea about two or three miles from the shore, and so many miles from any bar or outlet from the backwater has never been satisfactorily accounted for. From the circumstance of their being no natural outlet for the vast accumulation of waters which are poured down from the various mountain streams into the basin of the backwater, nearer than thirty-six miles on either side, it is not improbable that there exists a subterraneous channel communicating with the sea from the backwater, through which the large quantity of mud is carried off and thrown up again by the sea in the form of a bank. Being subject to tidal action, the bank is more or less shifting at certain seasons, but not to a material extent. It imparts a dirty-brown colour to the water for a considerable distance, and close to the shore the water is usually of a thickish consistency, being deeply impregnated with mud and slime".

Mr. Crawford, the then Commercial Agent at Alleppey, thus reports to the Resident of Travancore—date, 20th June 1860.—

Note.—This has already been printd on pages 73—75, Chapter IV.

**Para 232 of Report on the Administration of Travancore for the year 1881—82 (W. Logan).*

"This anchorage known to the pioneers of commerce as Mud Bay, is only apparent in the S. W. monsoon, and in 1849, its southern limit was ¼ mile N. of Alleppey, since which date it has steadily shifted to the South, and for the last three years has decreased in area each monsoon. The original theory seems to have been that the bank travelled year by year southwards and then suddenly resumed its original place; but from the various observations taken, this seems to be an error, and from the notes I have made during my 13 years' residence on the Malabar Coast, I believe that Mr. Crawford, the former Commercial Agent and Master Attendant of Alleppey, and who, in addition to 30 years' residence in Alleppey, had previous nautical experience of the coast, was correct in his conclusion that the bank of mud is created by the hydraulic pressure caused by the level of the vast backwater being, in the S. W.

*Borings taken near the flagstaff 20 feet thick, no less.

monsoon, some 4 feet higher than the sea. It has been proved by boring that although Alleppey appears to be one vast sand tract it has at a depth of 60 feet * a soft mud foundation, and both Mr. Crawford and I have seen mud volcanoes bursting up in the sea during the rainy season. Those that I have witnessed only appeared as if a barrel of oil had suddenly been started below the surface, but Mr. Crawford has seen some burst and throw up roots and trunks of trees, and it would appear that the mud bank thus formed is gradually carried down the coast by the littoral currents, and after a certain distance has been travelled, gradually wastes away, and that in place of this bank returning to its original position it is a fresh mud bank that is thrown up at certain periods in the vicinity of Alleppey, which, it should be noted, has the narrowest strip of land between the backwater and the sea. The theory that the mud bank is immediately connected with and due to the height of the backwater being above the sea was, I think, conclusively proved this monsoon, as at the height of the floods, when the canals were 6 feet above ordinary level, the area of the smooth water off Alleppey was so great that it was only by means of a good telescope and standing 20 feet above sea-level that I could see the breakers and heavy rollers beyond the half circle of smooth water. This flood was on the 13th June and was followed by a rapid fall, and the half circle of smooth water of the sea-beach contracted as the waters fell. The floods again rose inland, and the smooth water circle expanded in proportion.

This may explain the Alleppey bank, but Nairakal is fixed. I think, however, he is right.

"The mud itself is of a peculiar character and so soft that a light lead (4 lbs) put over the end of a pier apparently shows 2 fathoms of water, but on drawing up the line, 6 feet is found to be water and 6 feet soft oily mud.

"There are other points which, although I do not profess to sufficient scientific knowledge to show the connection between, with the mud bank, I think should be noted, as this natural smooth water anchorage has been a source of much discussion in scientific circles, and I believe that any notes given of the formation of the land must be of interest.

"I cannot give dates as I have no records, but it is certain that the coast from about north of Calicut to south of Quilon was once well above the level of the sea, and was after a long period totally submerged and then again was thrown up by volcanic action and has again been partially covered by sea. I state this because in cutting the Warkilli tunnel, trees were found, and also shells have been found on the coast which are known to belong to a class of shell-fish that only live in very deep water. Remnants of a fort at Poracaud were visible 30 years ago, and at Calicut and Vypeen massive buildings are now in the sea.

" Secondly, I should note that deep pot-holes exist in the big lake East of Alleppey of from 20 to 70 feet in depth, which, seeing that lake is for the most part only a few feet deep, is a curious circumstance and would tend to strengthen the belief that I have heard expressed, that subterranean rivers connect the backwater with the sea.

" The area of the lake to which I refer is nearly 100 square miles, and its nearest point to the sea, 3 miles. With a rise of 4 feet, or as occurred in the floods of 1882, of 6 feet, it can be easily believed that the enormous pressure thus caused would force relief ways for itself below the coast line through soft mud easier than through ground which is densely covered with cocoanut trees, the fibrous roots of which bind the ground into a solid mass.

" A similar mud bank exists off Narrakal, and I have often heard it put forward as an argument that mud banks on this coast do not shift, but I think the steadiness of the bank off Narrakal is due to the enormous body of water which pours out 6 miles south from the Cochin harbour and which scour throws up sand-banks which probably tend to prevent the shifting that would otherwise take place.

I would rather say the sand-banks at mouth of Cranganore river prevent the littoral current—N to S—from carrying it away. W. L.

" Other smaller mud banks occur at different places, but are of too small an area to be available for any shipping business, but they all show a progressive tendency southwards."

Narrakal, or Cochin Bank.—The only information I can find concerning this bank is from two papers in the Madras Journal of Literature and Science, (*) by Dr. Day and Captain Mitchell.

In the first, the following extract is given from Stavorinus, the Dutch Navigator, who so far back as 1777 wrote:—

" Coast is safe and clear everywhere along the Company's establishment, except at the mouth of the river of Cranganore, where there is a reef at the north side which stretches out to the sea, about three-quarters of a league; it is called the reef of Aycotia by our Navigators; before Coylang, (Quilon) there is a similar one but which does not extend half so far out. South of the above-mentioned mouth of the river of Cranganore, there is a bay, formed by mud banks: likewise one not far from Porca, and another south of Cochin: the banks forming which, extend full a league out to sea, and into which vessels may run with safety during the bad monsoon, and may lie in twenty and less feet of water, almost without anchors or cables, in perfect security against the heavy seas, which then roll in upon this lee-shore, as they break their force upon the soft mud banks, and within them nothing but a slight motion is perceived. "

Dr. Day continues:—

" In Horsburgh's East Indian Directory, fifth edition 1841, page 512, it is stated under the head of Cranganore Fort—'From the south point (of Aycotia or Cranganore river) a mud bank with 3 fathoms on it projects out near two miles to seaward '

" From the foregoing it appears that a bay protected by mud banks existed between the mouth of the Cranganore river towards Cochin in 1777 and then appears to have been well known. At present, the same protected spot exists, but it is no longer a bay, and for the following reason. Though the northern projection of the coast at the mouth of the Cranganore river, forming the northern extremity of the 'mud bay', is still present the southern projection, or that between Narrakal and the mouth of the Cochin river, is gone, having in fact been covered by the

(*) Vol. XXII, N. S. 6, pp. 260 and 264,—1861; " Narrakal or Cochin Mud Bank ". By Francis Day, Civil Surgeon, Cochin; and " The Mud Bank at Narrikal, near Cochin; its composition, as exhibited by the microscope". by Lieutenant J. Mitchell.

sea (at this place a church stood, which is now submerged): had it not been so, a 'mud bay' would still be present. It is curious that this law of encroachments of the sea is now the rule on the Western Coast, because tradition (*) and an examination of the geology of the country both lead to the conclusion that the sea formerly washed up to the Western Ghats; thus Malabar has been literally raised from the sea.

"During the south-west monsoon, the rivers on the Western Coast swell to a great extent, and become loaded with alluvial deposits. Should any obstruction occur at their outlets, deposits sometimes take place, as at the Cranganore and Quilon rivers, where mud banks have been so formed. Whether the impediment to the alluvial deposit being carried out to sea is merely owing to the action of the S. W. monsoon causing a great impetus to the waves as they meet the river at its exit, or whether other causes also obtain, must be questioned. In forming the Narrakal mud bank, a reef of rocks, the Aycotia reef, at the mouth of the Cranganore river, appears to have prevented the S. W. monsoon from causing a divergence of the river's mouth to the northward (as invariably takes place on the western coast unless that bank is protected); this reef (Aycotia) has probably assisted in the formation of the Narrakal, or, more properly speaking the Cranganore mud banks.

"The whole of the long islands, between the backwater and the sea, are evidently merely alluvial deposits, brought down by the various rivers in their course from the Western Ghats. The direction of these mud banks being the same as the long islands and the character of the soil being similar, demonstrates the causes of their origin to be probably identical. In short, the mud banks are alluvial matter, brought down by the rivers and deposited in the sea where it meets the force of the S. W. monsoon. (†)

"Though Narrakal, owing to its being the nearest place to Cochin is mentioned, the density of the water is greater proceeding

(*) In a MSS. account of Malabar, by Hernan Lopez de Castaneda, in 1525, it is said that little more than 2,300 years ago the sea came up to the Western Ghats.—(Note by Dr. Day).

(†) "During the S. W. monsoon, the sea for several miles beyond the entrance of the larger rivers is no longer salt."— (Note by Dr. Day).

towards the Cranganore river. It becomes very thick and black, and large pieces of flat, hard mud begin to be perceived lying on the shore, about one mile north of Narrakal, having been thrown up by the sea. Passing on towards Cranganore, a large bank of the same substance exists, evidently brought down by the river, and this is one source from which the mud bay receives a fresh supply."

* * * "No gases arise from the water, nor oily substance, (as has been suggested), floats upon it. It is simply the action of the sea which prevents the subsidence of the mud, for as soon as placed in a still vessel, it sinks. The shore is sandy, but amongst the sand alluvial deposit exists. The smoothness of the sea is well described by Stavorinus."

* * * "The mud has an unctuous sticky feeling, and is not gritty unless mixed with sand. It is of a very dark greenish colour, has but a slight odour and subsides in water—Cochin, 5th September 1861."

I have already referred to the organisms described in Captain Mitchell's paper, but he thus writes of the banks and the mud:—

"Captain Castor reports the existence of an extensive mud flat, which, commencing about half a mile south of the village of Narrakal, extends to the north for about four miles. Within this space, in the height of the S. W. monsoon, he found the sea without a ripple! But the greatest stillness of the sea and the total absence of surf from the beach prevailed between a village named Narambolum and Narrakal, a distance of about one and a half miles;—at this point Captain Castor was always able to embark from the beach in a small canoe.

"The mud appeared to be exceedingly soft, and permitted a 7-lb. lead to penetrate it to the depth of three feet in some parts where there was a superstratum of from six to ten feet of water. Beyond the depth of sixteen feet the bottom attains greater consistence and appears good holding ground. Three miles and a half from the shore the depth was five and a half fathoms and gradually shoaled towards the shore. We are left to conclude that the bank extends to that distance from the shore, but this is not distinctly stated in the published account.

"The small quantity sent to me was damp, and appeared very firm and tenacious; it had, however, been somewhat compressed by the waterproof wrapper in which it was packed. To ascertain, if it contained any minute shells a portion was placed in water, but it did not break up readily, and as I wished to avoid any violence that would destroy such delicate structures, I allowed it to soak for twenty-four hours. On shaking it up at the expiration of that time, I found that at least half of it could not be separated in that way. I therefore pressed it gently with a glass rod; it resisted the pressure, much in the way that a stiff piece of jelly would do, exhibiting considerable elasticity, as well as tenacity, and it is doubtless these properties that enable it to break the force of the waves:—acting like an immense spring, it yields to their pressure, but in the encounter the water loses its force and becomes quiescent, while the mud gently expanding again is ready for a fresh encounter".

I will now conclude this descriptive portion of my paper with a short geographical sketch of the country exhibiting these phenomena,— that is, from the Cranganore river southwards to Quilon. This range of coast is about 92 miles long: it is tolerably straight—without an indentation giving at all the form of a bay—except at the extreme ends, where, at Cranganore, there is the long southerly trending spit of the northern side of the river's mouth, by all accounts, for I have not visited it, a reef perhaps of laterite or lateritoid rock; and again at Quilon, where a sort of bay is formed by another great reef of laterite or lateritoid rock belonging to the Cuddalore Sandstones of the Survey classification, or the Warkilli beds of local geology. Much less is there any indication of a bay near Alleppey. The fact is, notwithstanding the argument of Dr. Day in the extracts given above, the term "Mud Bay", which has been applied to both places, may perhaps have been adopted for an imaginary bay of smooth water enclosed within the semi-circle of breakers outside. There is no doubt that a portion of the land near the Cochin end of the Narrakal bank was submerged; the church which stood on it having been known to men now living, but there is, I believe, no knowledge of this land having had the form of a projection like the southern arm of a bay. Be this as it may, the present shore line is a straight one from the Cranganore spit to the Quilon or

Tungumshery reefs; and it is low-lying or only a few feet above the level of the sea, and made up of alluvial deposits and sand. Inland from it, the same low-lying deposits, broken by back-waters, extend eastwards for several miles, forming the lowest portion of the low country proper of Travancore and Cochin. Then the ground rises, sometimes suddenly to a low terrace, now much cut up and broken by denudation, which forms the rest of the low country below the elevated mountain land or back-bone of this part of Southern India. The low country—that is, alluvial flats and inner low terrace—seldom attains a greater width than 30 miles.

The long stretch of alluvial deposits bordering the sea is broken by several backwaters or lagoons, the largest of which is that extending northwards from the parallel of Alleppey to, and communicating with, the backwater of Cochin. The Alleppey backwater is very wide at its southern end, 8 or 9 miles, but it is not directly behind Alleppey, much less behind the Alleppey-Poracaud mud bank; though the principal rivers entering it flow northwards behind the range of this mud bank. There is no visible communication between the Alleppey back-water and the sea; there being no river mouth of the least importance all along this coast, except at the Cochin backwater, and at Cranganore. The rivers of the country behind Alleppey, merely flow into the Alleppey backwater, and, for all that can be seen to the contrary, its waters flow out at the Cochin mouth.

To all appearance, the flat lands of the coast are entirely recent alluvial deposits; consisting of layers of sand and mud overgrown with vegetation, and no doubt held together by the roots of this vegetation. The water of the lagoons is more or less brackish and unfit for drinking; but shallow wells sunk in the narrow coast tracts between lagoon and sea give fresh water. It is not, however, certain—although it is most probable—that other deposits, besides the merely recent alluvial ones, exist along this coast; for at the Quilon end there is every reason to expect that the Cuddalore sandstones (laterite) are underlaid by a peculiar set of clays and muds, with seams of lignite and other vegetable matter, like those exhibited further down the coast at the base of the Warkilli cliffs. (See Rec. G. S. I., Vol. XV,

pt 2, p. 93). It is true that the dip of the Warkilli clays and lignite is to the northward and that they must, or ought—provided no disturbance has taken place,—to lie deep under the Tungumshery laterite; but this dip is very low, and a rise of these strata again further to the north would not be unusual. Certainly the lumps of blue clay, described by Mr. Crawford as being turned up in the "cones" of mud or water off Alleppey, answer to the lumps of clay which have fallen down from the lower part of the Warkilli cliffs: and the lumps of hard mud mentioned by Dr. Day as occurring at Narrakal, which I have also seen myself, have a similar constitution and looked to me as though they had been broken off from outcrops in the Narrakal sea bed. Mr. Crawford also mentions his having passed through a "crust or chocolate coloured sandstone, or a conglomerate mixture of that and lignite;" which strata answer very well to certain rocks at Warkilli.

The proper alluvial flats do not extend further east from the shore line than 14 or 15 miles; and the further inland alluvial flats of the rivers, which are very distinct and wide, do not extend further east than 20 or 22 miles: thus the absolute head of water which could be obtained in subterranean water-bearing strata would never be very high. Indeed, for all practical purposes, in this connection, the head of water looked for in the surmises of previous observers, can only be that attained by the flooding of the backwaters.

The term "volcanic" has been used occasionally by previous observers, perhaps rather as a descriptive term than as referring to any volcanic action; but the elevation or depression of the land is fully recognized as having taken place within comparatively recent periods. It is, however, a question whether there may not be an intimate connection between some of these earth movements and a line of volcanic action which, though now latent, is apparently indicated by the lie of the Maldive and Laccadive groups of coral islands, and yet further north the "Angrias" and "Direction" banks. At the same time, I do not wish to press this, possibly to some readers far-fetched, volcanic element into the discussion, except in so far as that it may not be lost sight of in future observations. Besides, as will be seen,

I do not think the observations made up to this time, or the theories offered in explanation of them meet all the features exhibited by these Travancore mud banks.

On a close review of the information given in the various papers above quoted, it is clear that both banks have practically the same constitution, behave similarly, and have the same accompaniments, with the exception of the violent discharges of mud or oil, which, so far as our knowledge goes, are confined to the Alleppey-Poracaud bank.

In considering first the mud itself of these banks, it is to be remarked that it is full of organic matter, and that it contains a sensible amount of oil, some of which may have been derived from the decomposition of organisms. In all seasons it is easily stirred up, and it never settles down into a uniformly compact deposit, but has an upper stratum in a greater state of liquidity than its lower depths. It occupies particular areas within well-defined ranges of movement; it certainly moves from north to south within these ranges, but there is no surety that it moves back again. This movement continues over periods of years.

Now, with regard to the progress southwards ceasing at certain points, as at the northern edge of the Cochin river mouth and at Poracaud. A satisfactory explanation can, I think, be given for Narrakal, in the Cochin river, which always flows out at a great rate, carrying the mud out to sea. We have no such mode of transport evident at Poracaud. The southerly movement must be attributed to littoral currents acting over long periods on tenacious muds, which may really only be evolved in large quantities at intermittent periods. Mr. Rhode's suggestion that the mud bank of Alleppey does not travel northwards again, but becomes dissipated at the southern extremity of its range, is very plausible.

Regarding the water over the mud: it is only known to calm down during the south-west monsoon. There is no observation showing how it may be affected in stormy weather at other seasons. Still I was led to understand, when in personal communication with Mr. Crawford (*) in 1881, that the calming of the

(*) Mr. Crawford is now living in retirement on the Peermede hills of Travancore, and it was here I had the pleasure of talking with him about the Alleppey coast, which he has known so intimately for more than thirty years.

anchorages does not take place until after the monsoon has commenced, and there has been a stirring up of the sea and mud. The quieting of the waters is intensified according to the amount of rainfall during the monsoon; but even if no rain falls, there is a certain amount of quiescence. The calmness continues throughout the monsoon, apparently without any fresh stirring up of the mud. In one locality at least, the water is subject at times to violent agitation through the bursting up of gigantic bubbles of water, mud, or gas, (it is not quite clear which); and these features also appear to be intensified during heavy rainy weather in the monsoon periods. The water over the banks becomes considerably freshened, even to the extent—as I was told by Mr. Crawford—of being drinkable; also, according as the monsoon rains are light or heavy. At such times, also, the water gives off fetid odours, and the fish inhabiting it are killed off in large numbers; but whether owing to the freshening of the sea-water, or the exhibition of poisonous matter and vapour in the water, is not clear: perhaps this destruction of life may be due to both causes.

The old idea of the mud bank acting as an elastic barrier against which the wild seas sank into such marvellous quietude, must be given up in part at least, now that we have got the more reasonable soother of troubled waters in the oily constitution of the mud. There is, of course, the difficulty of citing, or indeed the absolute want of, authoritative observation of the action of oil on troubled waters; but tradition and anecdote are undoubtedly in favour of it, while there are the newspaper accounts of the experiment which was tried a year or so ago in the harbour of Peterhead, when a stream of oil was cast upon the heavy seas at the harbour's mouth with such success, that vessels were enabled to run in with comparative ease. Even, while writing the present paper, I have had an opportunity of trying a very simple experiment on one of the Calcutta tanks, while a slight breeze rippled its surface. On throwing in about a wine-glassful of petroleum or earth-oil on the lee side of the tank, the oil spread out rapidly over the water against the breeze; the effect was instantaneous and decided, the sharp ripples being quieted down to longer smooth undulations, while there was a

distinct semicircular edge of the oiled water beyond which the ripples kept up their sharper action. In another place, on the side of the tank past which the breeze was blowing, a handful of the oil was thrown out on the waters. The oil immediately spread itself over the water in a thin film, along the outer edge of which the freshening breeze occasionally combed the wavelets, and within the area of the film the ripples were smoothed down to quiet and long undulations. The effect soon passed off, however, while the film of oil soon lost its sharpness of outline; so that it is evident if any continued quietness is to be kept up in water with oil, the supply of it must be continuous.

In the case of the mud banks, it can easily be conceived how the stirring up of the mud in the beginning of the monsoon should produce temporary calmness; but there is considerable difficulty in accounting for the long continuance of quiescence without any fresh stirring up. There is certainly the fact that the upper stratum of mud continues in an extreme state of liquidity, or attenuation in the water, and that, thus, a sort of restlessness and freeing of oil particles may be going on for a long period; but, I think we must look to a further supply from hidden sources, which are indicated by the more violent burstings forth of water, or mud, or oil, in the form of "cones".

An observation which would have been of the greatest use in this enquiry is wanting, however, and that is as to the condition of the surface of the water at such times, or, in other words, whether a film of oil exists on it.

The amount of oil derivable from the decomposition of the animal and vegetable matter of the organisms in the mud, would be, I am inclined to think, hardly sufficient to account for the features exhibited; hence it is necessary to look to other sources for the oil; and even to a source for the continued supply of the mud itself, which is evidently carried away and distributed by littoral currents.

The consensus of observation and opinion certainly leads to the conclusion that there is an underground discharge of water at any rate into the sea from the lagoon and river system behind the Alleppey-Poracaud coast during flood time, the inland

waters being at a higher level than the sea. The accounts of such a condition of affairs at the Narrakal bank are, however, not so clear; besides there is the free opening at the Cochin river-mouth. Still, underground discharges of lesser intensity may take place; while the lesser pressure, likely to be brought to bear on this part of the seaboard may also account for the absence of violent exhibitions like those off Alleppey. This passage of underground waters, as suggested by Mr. Crawford must then, more particularly during heavy rains, force out large quantities of the mud on which the Alleppey-Paracaud land rests, as it were like a floating bog, elastic and capable of yielding to pressure, or exerting pressure by its own weight; while a continuous stream, even though very small, of the same oil and mud, may be kept up under the lower pressure of ordinary backwater level. Not only would the underlying sludge and its products be forced out, but it is conceivable that the mud from the backwater should find its way into the same vents, and for a time replace that carried off in the first instance; oil and gases being absorbed in it during that time of replacement.

Excessive floods in the monsoon time only occur at long intervals; and the greater discharges of mud, oil and gases would then take place; in fact just as they really do at irregular intervals. At such times new banks might be formed; for, during the quieter intermediate season, the old ones might be distributed down the coast by littoral currents, and become finally dissipated into the open sea.

Be this as it may, if Mr. Crawford is right, then the source of the mud is evident, and its expulsion from beneath the Alleppey land is explained at once by the hydraulic pressure inland, if it even be only through a head of 6 feet at abnormal periods of flood time.

Speculation of this kind must, however, be kept in abeyance, until further evidence is obtainable as to the character of the sludgy stuff under Alleppey, and of the muds in the backwater, particularly over the deep holes referred to by Mr. Crawford, as also of the mud in the sea outside the banks themselves. A deep boring at Alleppey itself would clear up much obscurity, and it might tell more of the supposed Warkilli beds.

The presence of petroleum has in any case to be accounted for; and, up to this time there is no observation showing that it occurs in any of the lag oon deposits *per se*. There is at the same time an indication of the possibility of other deposits besides the alluvial ones, in the fact that large lumps of clay or compacter mud and vegetable-remains in a more or less decayed form, are brought to the surface during the prevalence of the violent ebullitions; Mr. Crawford, it must not be forgotten, also mentions his having met with a c hocolate-coloured sandstone or a conglomerate mixture of that and lignite. Such clays do occur in the Warkilli deposits, and they are associated with lignite beds, in which occur trunks and roots of trees in every stage of decay; some completely carbonized, and others so fresh, that they can be cut up and used for making furniture. It may then be that these Warkilli deposits extend northwards under the Alleppey-Poracaud alluvium, and even again at Narrakal, where, also fragments of similar clays are thrown up by the sea; and that it is from these deposits as being deeper-seated, older, and lignitiferous that the earth-oil is generated. I am even inclined to look further for an agent in the generation of this oil, like that adduced by Mr. Mallet in his paper on "The mud volcanoes of Ramri and Cheduba, (*)" where he suggests the possibility of oil and gas being generated in lignit ifereous strata under the influence of moderate heat arising from a line of volcanic energy; such a line, as I have suggested, possibly lying parallel to the west coast of India.

However, for the present, it is best to keep within the sphere of more evident causes shown by the observations which have been made. Thus, the conclusion seems inevitable, that the banks, their smoothening influence, and their position within certain ranges of the coast, may be entirely due to the following causes; First; the discharge of mud from under the lands of Alleppey-Poracaud and Narrakal, this being effected by the percolation or underground passage of lagoon water into the sea. Second; the presence in this mud of oily matter, derived perhaps in part from the decomposition of organisms, but principally from the distillation of oil in subjacent lignitiferous

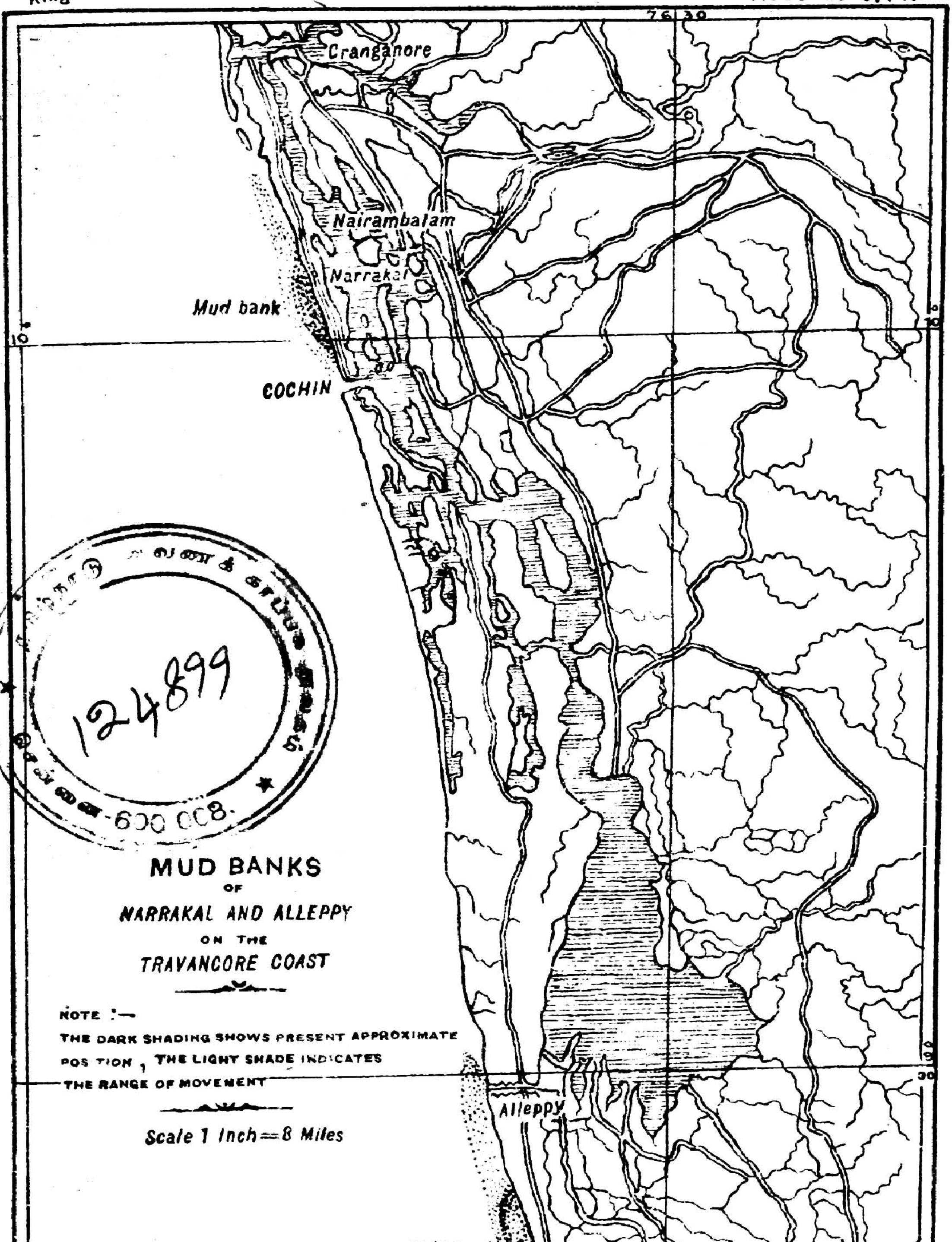
(*) Records, G. S. I. XI, Pt. 2, p. 100.

deposits belonging presumably to Warkilli strata. Third; the action of littoral currents which, slowly and through long periods of years, carry the mud down the coast to certain points whence it is dissipated seawards,—by the Quilon river at Narrakal, and at Poracaud because it is there beyond the range of replacement.

GEOLOGICAL SURVEY OF INDIA

King

Records XVII



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CHAPTER VI

EXTRACTS FROM THE

Records of the Geological Survey of India,

Vol. XVII, Part IV, 1884.

Pages 190 to 192.

Note on the smooth-water anchorages of the Travancore Coast.

By R. D. OLDHAM, A. R. S. M.,

Geological Survey of India.

CHAPTER VI

On the Travancore coast there are certain spots, where, in the height of the south-west monsoon, and on a coast exposed to its full force, ships can always anchor in smooth water. These anchorages have long been known to mariners, and have at various times attracted attention. In 1881 they were visited by Dr. W. King, Deputy Superintendent of the Geological Survey of India, who found that the mud which formed the sea-bottom was not only greasy to the touch, but on analysis proved to contain an appreciable quantity of oil to which he attributed the smoothness of the water; this opinion has, however, been criticised by a writer in the *MADRAS MAIL* (9th April last), who gave a totally different explanation, which I shall try to explain as briefly as possible.

In the open sea the particles of water which form the waves move in approximately circular paths, each separate particle moving upwards, then forwards, and so round by a downward and backward motion to its original position; as long as the waves are in deep water they move forward as rollers, but the water itself does not move forward except so far as it is forced forwards by the wind in a manner I shall explain afterwards.

Now, if these waves come on to a shelving beach, the particles of water are not free to move backwards in the lower part of their course, but are restrained by friction on the beach, and the consequence is that those particles which are moving forwards in their course get ahead of the others, and the wave curls over and breaks. But a solid shore is not necessary to make the waves break, for suppose it to be replaced by some liquid, like treacle or tar whose particles have not nearly the same freedom of motion as water, the lower part of the waves would be held back in the same way as by a solid shore, but to a less extent; so that the wave could travel further without breaking, but must break at last.

The theory of the writer in the *MADRAS MAIL* is this: we know that during the monsoon large quantities of fresh water are poured off the land into the sea, that on these mud banks

fresh water may sometimes be taken in alongside, that in any case the water at the surface is much fresher than sea water, and being in consequence lighter, floats out to sea on top of the heavier sea water. Now, the difference between fresh water and salt is of the same in kind as that between water and treacle, though less in degree; the separate particles of salt water have not so great a freedom of motion as those of fresh water; and if, as is the case in these mud-banks, the salt water is charged with fine mud, the difference is increased. Let us suppose, then, that outside the anchorage is a strip of sea where there is a shallow layer of comparatively fresh water lying upon muddy salt water. The great waves raised by the south-west monsoon roll into this, but immediately they reach it, the bottom of the wave is held back on account of the less freedom of motion of the particles, or the greater viscosity of the salt water; and, if only this layer of fresh water is broad enough, they will break and be destroyed. In this way the absence of the larger waves from these anchorages might be explained. But there is another class of waves, which, in comparison with the first, might be called ripples; these are not large enough to follow at anything like the same rate as the wind, for the larger a wave the faster it travels, and in consequence the crests are often blown over by the wind. It is to these that the small patches of foam are due which may be seen forming on the tops of the waves even in the open ocean, and which are often called "breakers" by landsmen, though their true nature is very different from that of the breakers formed on shore. I have not any definite information as to whether these may or may not be seen on the anchorages; if they are not, it is most probably due to the oil in the mud, which, however, would hardly account for the absence of the larger waves raised by the monsoon acting on hundreds of miles of sea.

At present so little is known of the facts regarding these anchorages that no proper explanation can be given, and it is with a view to obtaining the necessary information that the following interrogatory is issued. When the answers are collected we should be in a position to give the true explanation of these very peculiar and very interesting patches of smooth water.

GENERAL.

1. What experience have you had of the Western coast?

2. Are you personally acquainted with the smooth-water anchorages of Alleppey and Narrakal; if so, about how often you anchored there?

3. Do you know of any other similar places on the Western coast where smooth-water can be found during the south-west monsoon? If so, what kind of bottom is found on them?

4. What is your experience near the mouths of rivers and other places where the surface of the sea is covered with fresh or brackish water during the monsoons? Do the waves in six fathoms of water and over, generally run as large as in the open sea, or are they markedly smaller?

ALLEPPEY AND NARRAKAL BANKS.

5. Have you ever, during the south-west monsoon, known the sea over these banks to be salt—not merely brackish, but as salt as outside them? If so, was the water smooth or rough?

6. Of what size are the waves ordinarily seen during the south-west monsoon on the anchorages at Alleppey and Narrakal, and do they show broken water on their crests to any extent?

7. Have you ever noticed a film of oil on the surface of the water at Alleppey or Narrakal?

CHAPTER VII

EXTRACTS FROM THE

Geological Survey of India,

Vol. XVII, Part II, 1884.

Note on the Earthquake of 31st December 1881.

By R. D. OLDHAM, A. R. S. M.,

Geological Survey of India.

CHAPTER VII

On the morning of the 31st December 1881 a severe earthquake was felt over a large portion of the Indian peninsula and Bengal, affecting also the Burmese coast and causing much damage in the Andaman and Nicobar islands. A considerable amount of material, comprising newspaper extracts, official reports and private letters, having been placed at my disposal, I propose giving a brief notice of the more important features of the shock.

In Bengal it was felt as far as Chunar (?), Gaya, and Hazaribagh ; Akra, in the 24-Parganas, was shaken ; and at Akyab it was followed by the eruption of a mud volcano in Ramri.(*) There is no record of its having been felt at Rangoon or Moulmein ; at Tenasserim it is doubtful, though it was felt in the Mergui archipelago ; to the south it is reported as having been 'severe' at Acheen in Sumatra, and in N. Lat. 3° 54' E. Long. 91° 21' it was felt by the ship, Mount Stuart; at Ootacamund it is recorded, as also at Calicut : thus, the area over which it was felt measures about 1,600 miles from north to south and 1,500 miles from east to west, or 20,00,000 square miles in all.

Such briefly is the summary of the information contained in the daily papers, and as no observation of scientific value is recorded in them which has not been placed at my disposal in another form, I shall refrain from repeating the vague, when not misleading, statements of the time and nature of the shock which were so given to the world.(**)

There is, however, one published notice which contains much valuable information. I refer to the note by general Walker, and Major M. W. Rogers, R. E. (originally published in the Annual Report of the Trigonometrical Survey, and reprinted in

(*) Records, G. S. I., Vol. XV, p. 141.

(**) I may however, mention one letter by Mr. W. G. Simmons of Calcutta published in the Indian Daily News. He seems to have been at some trouble to collect information, and I have to thank him for liberally placing it at my disposal.

the Proceedings of the Asiatic Society of Bengal, March 1883, (page 60) on the records left by the earthquake, and its consequent sea-wave on the tidal gauges fixed along the shores of the Bay of Bengal, illustrated by reductions from the original records and a chart of the Bay of Bengal, on which Major Rogers has marked what he considered to be the focus of the disturbance. For the benefit of those who may not have access to the original, I subjoin a short abstract of the information contained.

At Port Blair, the forced sea-wave, indicating the arrival of the earth-wave, is indicated at 7h. 44'; (*) the first sea-wave arrived at 8 h. 3', followed by others at 15 minutes interval, with a height of 3 feet from crest to hollow, the disturbance not subsiding entirely till 21h.

Diamond Harbour.—Sea-wave hardly perceptible ; arrived at 15h. 10'.

Dablat.—First sea-wave at 13h.; disturbance continued till 21h.

False Point.—Forced sea-wave at 7h. 54'. Sea-waves small; the first arrived at 11h. 15'.

Vizagapatam.—The sea-wave arrived at 10h. 43' followed by others until midnight.

Madras.—Sea-wave arrived at 10h. 18'.

Negapatam. –The first wave, which arrived at 10h. 15' measured 4 feet from crest to hollow, and was followed by others until midnight.

Paumben.—First wave at 11h. 32'; disturbance lasted till midnight.

At Calcutta the time of arrival of the earth-quake was noted by Mr. James Murray, who writes, in reply to my enquiries, that he was reading in an upstairs room, when, feeling the shock he immediately ran downstairs and marked on the glass of his standard regulating clock the exact position of the second's hand

(*) These times differ from those originally given, having been retaken with greater care from the original records. The times here and throughout this notice are reduced to Port Blair mean time, and for the sea-wave are the time of arrival of the crest of the first wave.

and then waited to note the time of cessation of the motion; afterwards he carefully took with a second's watch the time that it occupied to do all he had done between the moment when he first felt the shock and when he made the mark on the glass of his clock; adding this and the error of the clock on that morning he obtained the times of commencement and cessation as 7h. 37' 45" and 7h. 42 ' 0" Calcutta mean time, or 7h. 55' 2" and 7h. 59' 17" Port Blair mean time, respectively. This, I may add, is the only observation of real value made at the time and not automatically recorded that I know of, in connection with this shock.

At Madras, a clock in the office of the Master Attendant, electrically controlled from the astronomical observatory, was stopped at 7h. 5' 45" local time, or 7h. 55' 36" Port Blair mean time.

Port Blair is the only place where any damage was done to masonry buildings, and it is to be regretted that the damage should be so little instructive as is the case. The infantry barrack, of which I have drawings showing the damage done, is a long narrow building situated on the crest of a hill, the major axis bearing N. 20° E., while the cross-walls bear E. 20° S. The latter were severely cracked, while with a single exception not a crack has opened in the longitudinal walls; this might indicate a direction nearly N. 20° E. or S. 20° W., but is most probably as will be seen from the sequel, due to their being of less solid construction. As regards the angle of emergence the cracks do not indicate much, merely pointing to a nearly horizontal or nearly vertical emergence; the former would be indicated by the fact that a chimney shaft 60 feet high was cracked but not overthrown as it certainly must have been by a severe shock with a moderate angle of emergence, but as this supposition is irreconcilable with the position of the seismic vertical obtained from more trustworthy observations, we must suppose the angle of emergence to have been nearly horizontal and the violence of the shock to have been considerably exaggerated.

In the Car Nicobar, extensive damage was done to the cocoanut groves and huts of the natives, and vents similar to those described in connection with the Cachar earthquake of

1869 (*) were opened in the sandy soil. It was noted by major W. B. Birch, to whose report I am indebted for the facts, that on the margin of the seashore the trees were left standing, while further inland they were overthrown. This may have been due to the fact that the edge of the land was protected from the earthquake by the slope of the seaward face being steeper than that of the emergence of the wave, but I am inclined to believe that Major Birch's suggestion, that the soil near the sea margin is firmer than that further inland, is more likely to be the true explanation. The sea-wave broke on this island and it is recorded that the water penetrated into the houses of the Burmese residents which stood on platforms of less than 2½ feet high, while those on higher platforms escaped.

I will now proceed to the discussion of the data available, which are, firstly the records of the arrival of the earth-wave at Calcutta, Madras, False Point, Port Blair, and Kisseraing; and secondly, the records of the arrival of the sea-wave at the stations mentioned above; the latter, however, are owing to irregularities in the depth of the Bay of Bengal of no use in determining the position of the seismic vertical. Of the first category, the records from Madras and Calcutta are undoubtedly good, those from Port Blair and False Point are good as far as they go, but only pretend to give the time to the nearest minute, while the fifth is, as will be subsequently shown, unfortunately open to an element of doubt.

It has been pointed out by Professor Milne that if the earth-wave arrives at two points on the earth's surface at the same moment of absolute time and a straight line be drawn joining those two points, the seismic vertical should lie somewhere on the line bisecting it at right angles, supposing, that is to say, that the surface of the earth were a plane and its substance homogeneous; on the same suppositions if the time of arrival is known at three stations and circles be drawn round the two at which the arrival was latest, with radii equal to the distance traversed by the wave in the respective absolute differences of time between its arrival at those stations and at the first station, and a circle be drawn passing through the first station and

(*) Memoirs, G. S. I., Vol. XIX, part I.

touching the circles drawn round the second and third stations, the centre of that circle will represent the position of the seismic vertical. Neither of the assumptions are, of course, theoretically correct, but these constructions give a rapid and convenient method of finding the approximate position of the seismic vertical. I have for the purposes of the first construction, taken the time of arrival at Calcutta and Madras as identical and represented it on the map by fine, firm lines; the second construction is not represented, but the centres obtained are indicated by dots with the letters C. M. B. for the centre deduced from the Calcutta, Madras, and Port Blair observations, and F. M. B. for that due to those at False Point, Madras, and Port Blair. It will be seen that the first-named lies within 30 miles of the true position of the seismic vertical, the error being due almost entirely to the unavoidable distortion of the map; the other shows a greater error, due partly to a less average accuracy of the observations and partly to the fact that the stations are less favourably situated for applying the construction. Taking Calcutta, False Point, and Port Blair, we get an impossible centre at the mouth of the Irrawadi, the fact being that this construction is only practically applicable when the three stations form a pretty open triangle. The Madras, False Point, and Kisseraing observations give the centre where Major Rogers placed it, but this result is vitiated both by the small inaccuracy of the False Point observation and the greater one at Kisseraing, which will be referred to hereafter.

Starting with the C. M. B. centre, a brief investigation proves it to be about 30 miles too far south; so taking Lat. 15° Long. 89° as the centre provisionally, we find that the geodetic distance from this point to

		Feet
Port Blair is	...	18,04,475
Calcutta is	...	31,17,585
False Point is	...	28,88,620
Madras is	...	31,77,850
Kisseraing is	...	35,63,660

Subtracting the distance to Port Blair and dividing the results by the respective differences of time, we get a velocity of transit as between Port Blair and

		Feet per second
Calcutta of	...	1·957
Madras of	...	1,948
False Point of	...	1,807
Kisseraing of	...	2,666

and as between Calcutta and Madras of 1,746 feet per second—a not impossible result, as the difference of distance would lie mainly in alluvial deposits, though possibly indicates that the centre is about half a mile east of the position assumed.

The low velocity as between Port Blair and False Point is easily explicable by the fact that the observations are only given to the nearest minute, had the time interval been 9 minutes instead of 10 minutes, it would give a velocity of 2,001 feet per second, while an interval of 9¾ minutes would bring it almost into accord with the Calcutta and Madras observations. From this we may conclude that the time recorded at Port Blair is too early, or that at False Point too late, or possibly both. It must be borne in mind that the times were taken from the trace left by a pencil on a sheet of paper and on a scale on which it would be difficult to distinguish between, say 7h.53' 15" and 7h.53' 45", though one should be recorded to the nearest minute as 7h.53' and the other as 7h.54'.

The Kisseraing observation, however, gives a velocity which is inexplicable on this supposition, and I cannot but consider the error due to an actual error of observation, as, though it can be approximately reconciled with those from the western stations, this can only be done by taking the latter out of accord with each other and giving an inadmissibly high velocity to the whole series. The only published record of this observation is that in Major Roger's note, where he says that "at Madras, False Point, and Kisseraing the shock was felt at about the same minute—7h. 55' A. M.;" it will be seen that this is rather vague, and a personal application to Major Rogers elicited the fact that the original record had been destroyed, and it was consequently no longer possible to estimate the degree of accuracy of the time record. I fear we must reject this observation as of insufficient accuracy for the purposes of the investigation.

The position assumed above proves to be that which best reconciles itself to the excellent observations at Calcutta and Madras, and to the automatic records at Port Blair and in a less degree False Point; I shall consequently consider that the shock did originate vertically below a point situated in Lat. 15° N., and Long. 89° E., and that it travelled with a velocity of 1,950 feet per second, being that indicated by the Madras and Calcutta and Port Blair observations. Under these circumstances the time taken by the earth-wave to travel from the seismic vertical to

Port Blair would be	15' 25"
Calcutta	26' 39"
Madras	27' 9"

(I omit Kisseraing and False Point owing to probable inaccuracies of the records).

Subtracting these intervals from the recorded times, we have the Port Blair mean time of the origin of the earthquake deduced from the

Port Blair record as	7h. 28' 35"
Calcutta	7h. 28' 23"
Madras	7h. 28' 27"
Mean	7h. 28' 28"

But as the Port Blair record is liable to an unknown error being merely to the nearest minute, the mean of the Calcutta and Madras results, viz., 7h. 28' 25", is probably more accurate. Taking this result and reckoning back to the various stations we get the true time at

Port Blair, 7h. 43' 50"	instead of	7h. 44',	a probable error of	*plus* 10"
False Point, 7h. 53' 6"	,,	7h. 54'	,,	*plus* 54"
Kisseraing, 7h. 58' 58"	,,	7h. 55'	,,	*minus* 3' 58"

The depth of the focus below the level of the sea cannot unfortunately be ascertained, the only records that could give the angle of emergence being from Port Blair and, as mentioned above, they are indefinite, and all we can say is that the emergence was nearly horizontal; from this we would deduce a focus situated at a small depth, probably about 5 or 10 miles, and being improbably over 15 miles from the surface.

In the shape of the area over which the shock was felt there is a notable peculiarity as regards its eastern boundary between Akyab and Tenasserim, which seems to be real and not merely due to insufficient information, for Rangoon and Moulmein are large cities with a considerable resident European population, so that the shock if felt could hardly have escaped record. (*) In the Mergui archipelago it is recorded as slight, and it is very doubtful whether it was felt at Tennasserim. To the south, west, and north the configuration is very different; the shock is recorded as severe at Acheen; it was felt by the ship Mount Stuart in N. Lat. 3° 54' E. Long. 91° 21'; to the west it was felt at Calicut; and to the north is said to have been felt at Chunar, though Gaya is possibly the extreme limit. This peculiarity may in part be due to a difference in the rocks traversed, but not being fully accounted for in that manner clearly indicates that the shock had its origin in a fissure underlying strongly to the west. If we accepted the Chunar record, it would almost be necessary to suppose the fissure curved and bending round from about S. W. to S. E. rejecting it, we come to the conclusion that this earthquake had its origin in a straight, or nearly straight, fissure bearing about N. W. and S.E. and underlying to the S.W., a far more probable configuration than the first, and one which is not absolutely incompatible with the Chunar record, if that is correct.

When we come to examine the records of the tide gauges the first point to be noticed is the absence of any record from the stations on the Burmese coast, while the wave is shown to have reached points on the western coast of the Bay situated at a greater distance from the centre. This, however, ceases to be remarkable when we examine the records from the stations on the delta of the Ganges. At Dablat the height of the wave is 12 inches, while at False Point it is but 2 inches, and merely perceptible at Diamond Harbour; if on the delta of the Ganges, exposed to the full force of the wave, the mere shoaling of the

(*) As this note was passing through the press a paper on 'Earthquake disturbances of the Tides on the coasts of India', by Lieutenant-General J. T. Walker, C. B., F. R. S., etc, appeared in 'Nature', February 14th, in which it is incidentally mentioned that the earthquake was felt at Rangoon and Moulmein.

waters produced such an effect, it is not surprising that a similar shoaling at the mouth of the Irrawadi should have entirely destroyed the wave already enfeebled by the barrier stretching between Cape Negrais and the Andaman islands.

Between the centre and Port Blair the wave must have travelled by a circuitous route, and as it is impossible to say what allowance is to be made for this it becomes impracticable to correctly calculate the rate at which it travelled. In all probability the first wave recorded came round the south of the island, while the curve bears ample evidence that the subsequent long-continued and complicated disturbance was due to the interference of the two sets of waves—one travelling from the north, the other from the south.

Taking, for convenience of calculation, the time of origin of the wave as 7h. 28' 30", the error so introduced being comparatively insignificant, and in any case certainly not greater than that due to want of accuracy in the records, we find that the mean rate of transit of the wave between the centre and

	Feet per second
Paumben is	281
Negapatam	359
Madras	311
Vizagapatam	173
False Point	213
Dablat	104

Of these, the difference between the mean rates to Negapatam and Paumben is due to the long stretch of shallow water crossed in the latter case ; but the difference between Madras and Negapatam is noticeable, and is probably due to the shallowing of the bay by the deposit in it of the silt brought down by the Kistna and Godavery rivers ; this same cause has evidently affected the velocity between the centre and Vizagapatam, while the increase in velocity between the centre and False Point indicates that the wave has travelled over the depression between the two banks caused by the deposit from the Kistna and Godavery on the one hand and the Ganges and Brahmaputra on the other.

This notice, besides its direct bearing on the earthquake

in question, shows the great value of a few really accurate time observations which, taken in conjunction with such simple observations as are within the power of all to make, have enabled me to fix the position of the seismic vertical, the velocity of transmission of the earth-wave, and the approximate form of the focus ; had it originated inland there might not improbably have been sufficient information available to fix the depth of the focus—in the present state of our knowledge, one of the most important, if not the most important point to be determined with some degree of accuracy. Under these circumstances it is unfortunate that in the system of seismological observations recently sanctioned by Government an accurate determination of the time could not be incorporated, but with the unskilled even where not unsympathetic observers who are alone, as a rule, available, it would be impossible to secure that accuracy of record which alone would be of use ; for this is especially a case where an inaccuracy, where accuracy is looked for, is worse than no record at all.

The following facts, though not strictly related to the earthquake under consideration; may with advantage be put on record here.

The master of the ship Commonwealth, reported that he felt three shocks of earthquake on the 1st January 1882 in N. Lat. 8° 20', E. Long. 92° 42', and that the whole of the Car Nicobar was hidden by smoke. Major Birch, on his subsequent visit to the island could find no foundation for this statement, so that in all probability it was only the smoke of a fire that was seen.

This shock was stated in the daily papers to have been felt at Khatmandu, in Nepal; but to judge from the more detailed information placed at my disposal, this cannot have been the same shock.

CHAPTER VIII

EXTRACTS FROM THE

Geological Survey of India.

Vol. XXIII, Part I, 1890.

Pages 41 to 47 and pages 2 and 3.

Notes on the Mud Banks of the Travancore Coast.

By PHILIP LAKE, B. A., Geological Survey of India.

(with one plate),

and Annual Report of the Geological Survey of India.

CHAPTER VIII

The mud-banks, or smooth-water anchorages of Alleppey and Narrakal on the Travancore-Cochin coast, have been known for many years, and much has been written about them. A very full account of the literature of the subject has been given by Dr. King, in the Records of the Geological Survey of India (Vol. XVII, pp. 14—27), and to his paper I must refer for a general account of the banks.

The chief object of my visit was to see in what way the bursting of the south-west monsoon and the rising of the back-waters affected the condition of the mud-banks. It unfortunately happened, however, that this year (1889) the monsoon did not begin at Alleppey with its usual suddenness, and the season was consequently not very favourable for my purpose.

As most of my time was spent at Alleppey, it will be best, first, to give an account of what I saw there, and then to describe the few observations made at Narrakal. To Mr. Rhode, the present commercial Agent at Alleppey, I am indebted for several important observations and much valuable help, and especially for a table showing the changes of height of the backwater during the days of my stay. It is to the observations of Mr. Rhode and of his predecessor, Mr. Crawford, that we owe most of our knowledge of the Alleppey mud-bank, and there is little to add to what they have already recorded.

The mud-bank at Alleppey, though some miles long, is mostly hidden under the sea, and only a very small part of it appears above the surface. The actual northern end of the bank, which is some distance from shore, seemed to remain at the same point throughout my stay at Alleppey; but the visible part of the bank moved gradually southwards.

On the 4th June, mud appeared close to the pier, and the water there was very thick and smooth. For a considerable distance out to sea, and along the coast, though no mud was visible, the water was much smoother than in the open ocean. About half a mile north of the pier, the sea came in with its full

force and with a great surf. The northern end of the mud-bank, as was afterwards proved, lies almost directly off this point.

The smooth-water tract was semi-circular in shape, and its northern and southern edges were defined by two crescentic lines of breakers running outwards to the sea; but towards the west there was no distinct boundary between the smooth and the rough water. The waves became lower and lower as they approached the shore.

Where the water is smooth, the sandy shore is wide and slopes gently to the sea; but where there is a surf, the shore is narrower, and the part of the beach upon which the waves break is very steep.

On the 7th, the visible part of the mud-bank had moved a little to the south; and one of the peculiarities of the waves, as they approach the bank, was very clearly marked.

About half a mile north of the pier the waves came in with full force, and their crests were parallel to the shore. When, however, a wave passes over the mud-bank, not only is its height diminished, but its velocity becomes less. The southern part of a wave is here over the mud-bank, while the northern part is still over a sandy bottom. The part over the mud-bank is impeded in its motion, while the northern part still rushes on with its full speed. The consequence is that the crest of the wave, instead of running parallel to the shore, i. e., about N by W, becomes oblique to it and runs N. E. The obliquity of the waves becomes greater and greater to the south, till finally, on this particular day, at the pier, the crests were at right angles to the shore and the waves ran from N to S. This is shown diagrammatically in fig. 1.

The case is the same at the south end of the bank, as observed on the 13th. There, however, it is the northern part that reaches the mud-bank first. Consequently, the waves become oblique to the shore in the other direction, and run up the coast from south to north. The phenomenon is not so clearly marked as at the north end of the bank.

On the 13th, the part of the bank that appeared above the sea had reached a point about a quarter of a mile south of the

pier. The waves came in diagonally at the pier, and about a quarter of a mile south ran from N to S along the shore.

Except for this slow movement to the south, there was no change of importance till about the 15th. On the evening of the 14th, the backwater, which had been slowly rising, stood 6 inches higher than on the evening of the 4th.

On the 15th, a strip of shore close to the sea had subsided some two or three feet. The width of the strip was about 20 yards and its length about 300. The point of maximum subsidence was a little north of the pier; and from this point to the north and south, the amount of the subsidence gradually decreased till at a distance of 100—200 yards from the central point all trace of it had disappeared.

Further north, however, a semi-circular area (the diameter being the actual sea-border) had begun to fall. Instead of subsiding in one piece, this area had sunk in little steps, so that there were a number of little terraces rising one above another from the sea towards the east. The height of the terraces was only a few inches.

At the north end of the semi-circular area, just within the sea, a heap of mud rose above the waves. This heap was surrounded by a channel or moat, and had the appearance of having been forced up through a hole at the bottom of a crateriform basin. The mud rose in a sort of column to a height of two or three feet above the level of the sand. It was very soft, but so tenacious that it was very little affected by the waves which washed over it.

North of this point there were no signs of disturbance of any kind. But all along the seaward edge of the subsided areas there were a number of basin-shaped holes in the sand, about four or five feet across and three or four feet deep.

On the 16th, the subsidence at the pier had increased, and just within the sea, a long ridge of mud had risen above the waves. This ridge extended, with a few interruptions, to the mud heap observed the day before.

Some of the crateriform holes had become partially filled up

with sand. The moat surrounding the mud heap of yesterday was also filled up. It appeared that the column of mud rising in its centre had gradually collapsed. Probably owing to the pressure of mud above, that at the base had begun to flow outwards. By sounding with a stick, I found that the section across the heap was as in fig. 2.

It was impossible on this day, owing to the treacherous nature of the mud, to cross to the seaward side of the line. But on the 17th, enough sand had been thrown on the lower parts of the ridge to form a tolerably coherent layer. It was then possible to cross at some points, and I was able to sound the mud heap right across, the result being shown in the figure. The mud fills a basin-shaped hole, the seaward side of which is steeper than the landward side. In the middle I could not reach the bottom of the mud.

A section across the long continuous ridge of mud further south, was nearly the same as fig. 2, but it was there impossible to get to the saward side.

It is clear, then, that the mud is forced up from below through the sand. As it rises, the sand sinks in round the hole or cleft through which the mud is forced and a basin or trough is formed which the mud afterwards fills.

As soon as the ridge of mud rose above the waves, rounded masses of mud were thrown up on the beach. These were, no doubt, torn off from the mudheaps and rolled about in the waves.

On the 18th and 19th, the water in the backwater had risen to the greatest height at which it stood during my stay at Alleppey. No further subsidence took place and the backwater now began to fall slowly.

After this date there was no change in the mudbank till my departure on the 24th; but a few more points remain to be noticed.

The mud thrown up in the manner described is precisely like that found by sounding at considerable depths. It is greenish in colour, very oily-looking, and very tenacious. There is no visible foreign matter mixed with it. But where the water is smoothest and muddiest (at this time, about a quarter of a mile

south of the pier), it is full of blackened twigs, etc.; and palm tree roots and pieces of wood are thrown up in quantities. At first sight it appears as if these came out of the mud of the bank. It is more probable, however, that they have been brought down the coast by the current which runs from north to south, and have naturally been collected in such a piece of smooth water as this, just as, in a rapid river, twigs and straws collect behind any projecting point that gives them shelter.

Moreover, it has been already mentioned that the waves approaching the mudbank converge towards this point, and sweep along the shore from the north and the south.

Many of the pieces of wood are rounded and appear water-worn, and they are often bored by *Pholas*. It may be remarked, too, that large numbers of sea-shells are thrown up at the mud-bank, and not elsewhere; and that more sand collects along the edge of the smooth-water tract than where there is a heavy surf (1).

The smooth-water tract is in fact a sort of refuge for everything thrown into the sea any where within a reasonable distance, and the presence of vegetable matter, even green and fresh, in the mud volcanoes observed by Mr. Crawford (2) ,is perhaps due to this.

On the 21st, the smooth water was more extensive than before, and the whole area of the water was variegated with broad shining streaks. On rowing up to these and examining them, I found that the water of the streaks was much less rippled than

(1) When the Alleppey pier was built, the mud-bank lay far to the south. The shore at Alleppey was then narrow, and the pier stretched well out to sea. Since the new mud-bank formed near the pier, sand has collected, until now the sea reaches only the extreme end of the pier.

(2) Mr. Crawford (see Records, Vol. xvii, p. 18) speaks of the bursting of the cone of mud, and the throwing up of boulders of mud and vegetable debris. I did not see any cone burst, and the boulder-like lumps of mud and debris on the shore were simply thrown up by the sea.

None of the outbursts in the bed of the roads, which seem to be more striking than those on the sea-border, occurred during my stay.

elsewhere, and was covered by a thin film, most clearly visible with the light of the sky reflected at a particular angle. The film was too thin to be collected, but was probably oil, and certainly had a smoothing effect on the smaller waves. There were several of these broad patches of film-covered water, and they extended some miles out to sea.

Narrakal.

At Narrakal, on the 2nd June, the mud-bank was heaped against the shore and a very large area was above sea-level, so that a channel had to be opened to enable boats to reach the sea. Owing to the liquidity of the mud, the channel was constantly filling up; but it was possible to row a light boat over the mud even where no water appeared.

The sea was much smoother than at Alleppey, and the smooth water extended some distance south of the pier. I observed several of the shining streaks afterwards noticed at Alleppey, but, probably owing to the nature of the light, could only find a film at one or two places. Wherever the water shone, however, the ripples were much smoother than elsewhere.

On the 25th I paid another visit and found the bank and smooth water in nearly the same condition as before. But on going to the edge of the smooth water I found that the rougher water was blue and the smoother, muddy in colour. On the smoother water was a film as at Alleppey, and its edge was marked by a line of bubbles and foam. The crests of the waves broke slightly as they entered the muddy water.

The boundary between the blue and muddy water was so well defined that sometimes on one side of the boat the water was deep blue and on the other a reddish-grey. Within the blue water, however, were some muddy-coloured streaks as if the edge of the muddy water had been so to speak, frayed out in places.

The only way to account for so sharp a boundary seems to be to suppose a current of clear water to run in a south-easterly direction along the outward edge of the mud-bank, and to strike the shore some distance south of Narrakal, where the muddy water now ends.

That such a current does exist is well known, and it is to it that the heaping up of the mud-banks at the pier is due. Narrakal lies in a shallow bay protected from this current by the slight projection of the shore to the north. The current sweeps by this projection and strikes the shore south of the pier. The greater part of the mud collects in the protected bay.

During heavy south-west monsoons, however, I was informed on the spot, the mud is swept out of the bay (which is quite open to the south-west) and does not begin to collect again until the southerly current recommences.

From the structure of the mud heaps at Alleppey as already described, it appears that they have been formed by the forcing up of mud from below. There must therefore be a stratum of similar mud at a certain depth below the sand.

It was not until the ground had become thoroughly soaked (as shown by the rising of the water in the wells) and the backwaters had risen slightly, that the eruptions of mud took place.

All this is simply confirmatory of the observations of Messrs. Rhode and Crawford. They have shown that when the backwaters rise, the extent of the smooth-water tract increases, and mud volcanoes burst in the sea. Borings made at various places have reached mud at depths varying from 20 to 66 feet. Between the sand and the mud Mr. Crawford found a crust of chocolate-coloured sandstone.

Mr. Rhode informed me that in making the pier, the screw-piles went in for some distance without difficulty. They then met with considerable resistance, but, this once overcome, they went in easily for the rest of the way. The outermost pile, however, went in from the very first with great, in fact too much, ease. If we supposed the piles to pass through the same beds as were met with in Mr. Crawford's boring, the peculiar behaviour of the screws would be explained. They first passed through sand, then "chocolate-coloured sandstone," and lastly mud. The outermost pier entered the mud at once.

It may be assumed therefore, that under the sand of Alleppey is a layer of mud which crops out under the sea: When the

backwaters rise to any height, the pressure forces this mud out under the sea and forms the mud-bank.

This is, I believe, the theory of Mr. Rhode; but that this mud is the backwater mud is very doubtful. There is not the least resemblance between the two. The mud of the bank is greenish in colour, oily, very tenacious, and owing to its fineness very miscible with water (1).

It is a very fine clay, and of ordinary clays, is more like the under-clay of a coal-seam than any other. The mud of the backwater, on the other hand, is full of vegetable debris, black, lumpy and contains a high percentage of carbon. It will not mix well with water, and is hardly a true mud.

I am inclined to think that the stratum of oily mud will be found at some depth below the backwater deposits, and that, in fact, it was the silt carried by the rivers into the sea when the coast-line was further east than it is at present, before the sand-bars cutting off the backwaters from the sea began to be formed.

According to the observations of Messrs. Crawford and Rhode, carried on through a long series of years, the mud-bank is formed at intervals at Alleppey, and is then gradually washed southwards by the littoral current, being slowly dissipated by the waves at the same time. Usually, before the old bank has quite disappeared, a new one starts at Alleppey.

This year, for example, at Totapallicherra, (about 13 miles south of Alleppey), there were the remains of an older bank, which had travelled southwards from Alleppey. I found it fairly well marked; but only in one point was there any trace of it visible above the sea.

As the bank is always formed at Alleppey, we may assume that the outcrop of the oily mud stratum lies there, and that the bed thins out to north and south.

A small mud-bank, in all respects similar to that at Alleppey occurs at Calicut; and in boring for foundations for the bridge over the Kallai river, a layer of oily shale or mud was passed through. This stratum thinned out to north and south, as was

(1) It seems to take some time for this mud to become thoroughly mixed with water; but when once mixed, it will remain so for a long time.

proved by other borings. The mud was in character very like that of the Alleppey and Narrakal banks. I have not the full details of the borings with me, but the shale was found in association with beds containing shells and fish-bones. It was obviously laid down by the river when the current at that point was slow.

No connection has been proved to exist between this bed and the Calicut mud-bank; but the presence of such beds among the river deposits of the West Coast, at least, suggests that they may sometimes crop out under the sea; and if there were sufficient pressure during the monsoon on their inland portions, the mud would naturally be squeezed out at its outcrop and would form a mud-bank.

Owing to the peculiarly fine nature of the mud, it is stirred up by the waves, and in that condition would easily be carried south by the littoral current. It is hardly necessary to repeat any of the observations made showing the liquidity of the mud when well mixed with water; but an ordinary lead will frequently sink four or five feet into the mud.

The chief point, then, in which I differ from previous observers, is in considering that the Alleppey bank is formed, not from the backwater mud, but from an older river deposit, found only at particular points along the coast. This would explain its non-appearance at other points where the conditions seem equally favourable. With regard to the existence of actual subterranean channels, it may well be doubted whether any could exist in such unstable deposits as are found here.

The Narrakal mud-bank is very probably, to a large extent, formed of the silt carried down by the Cranganur river. It does not appear to be very much affected by the rise of the backwaters. It is, in fact, very much what the Alleppey mud-bank must have been before the greater part of it was covered up by more recent deposits.

It has already been shown how the Narrakal mud collects in an area sheltered from the ordinary littoral current, and is occasionally partly dissipated when the monsoon current sets in.

The next point to be considered is the manner in which the mud exercises its peculiar smoothing power on the waves.

The mud, as has already been mentioned, is very oily in appearance; and it has been shown by Dr. King to contain a certain amount of oil. I have myself observed a film of what I supposed to be oil, on the surface of the smooth water; and found that where this film existed, the water was smoother than elsewhere. But it did not appear as if the whole effect of the bank could be due to this oil. There was no sharp line between the rough and the smooth water, except at the north and south ends of the banks. As a rule, the waves simply became smaller and smaller as they neared the shore, and at the same time the period of vibration seemed to become longer and longer.

From the manner, in which the waves approach the shore, as observed on the 7th and following days it can be shown that their velocity over the mud-bank is less than their velocity over the ordinary sandy bottom. This is easily explained when we remember that over the bank the water, especially the deeper water, is mixed with mud, and this mixture is heavier than pure sea-water; and that the velocity of a vibration varies, when other things remain the same, inversely as the square root of the density of the medium through which it is propagated.

It is to the same cause that we must attribute the decrease in amplitude or size of the wave. As there is more mud mixed with the water at a little depth than there is at the surface, the lower part of the wave is retarded most, and hence the upper, or visible part of the wave, sometimes breaks when it reaches the bank. But if the retardation is more gradual, as would be the case when the bank is first encountered at a great depth, there is no surf, but the wave gradually becomes smaller and smaller.

It is on account of this that the smooth-water tract is defined at its northern and southern borders by a line of breakers, while straight out to see there is no distinct boundary. At the north end, the wave does not meet the bank till it reaches a depth of less than two fathoms; while off a point a little south of the pier, the waves are over mud at a depth of 4½ fathoms or even more.

Extract from the Annual report of the Geological Survey of India, Volume XXIII, 1890, Part I, Pages 2 ana 3.

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Smooth-water tracts of Travancore.

After the close of the working season, and just as the south-west monsoon was expected to be in full force, Mr. Lake was sent down to Alleppey to study the action of the famous smooth-water tracts, or mud-banks, which present so strange a feature on that coast. As usual, when an opportunity occurs for reviewing peculiar physical features of this kind, the monsoon was not so strong as might have been expected; but such effects as Mr. Lake could study were enough to explain in great part the features displayed. I had myself already ascertained that there is a sensible amount of oil contained in the mud of the banks underlying the smooth tracts around which the rollers from the south-west break in greater or less force during the monsoon; and had ventured to suggest that the stirring up of such oleaginous mud, and possibly the increased discharge of oil at the stormy period, might have some very decided influence in the smoothing of the waters. Mr. Lake's study does not, however, lead him to consider that the oil has more than a partial influence in this direction; the main cause being attributable to the increase of the density of the water when mixed with the mud. The discharge of oil seems to be increased, a thin coating of it being clearly recognizable in patches on the surface of the water; but this is altogether insufficient to encourage the hope I had formed of there being any deep-seated source of oil warranting exploration by boring into the tertiary lignitiferous deposits known to underlie many points at this and other spots on the Travancore, Cochin, and Malabar Coast. A paper by Mr. Lake appears in the present number of the Records.

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Calcutta,
January 31st, 1890.

WILL KING,
Director, Geological Survey of India.

GEOLOGICAL SURVEY OF INDIA

Lake

Records Vol. XXIII

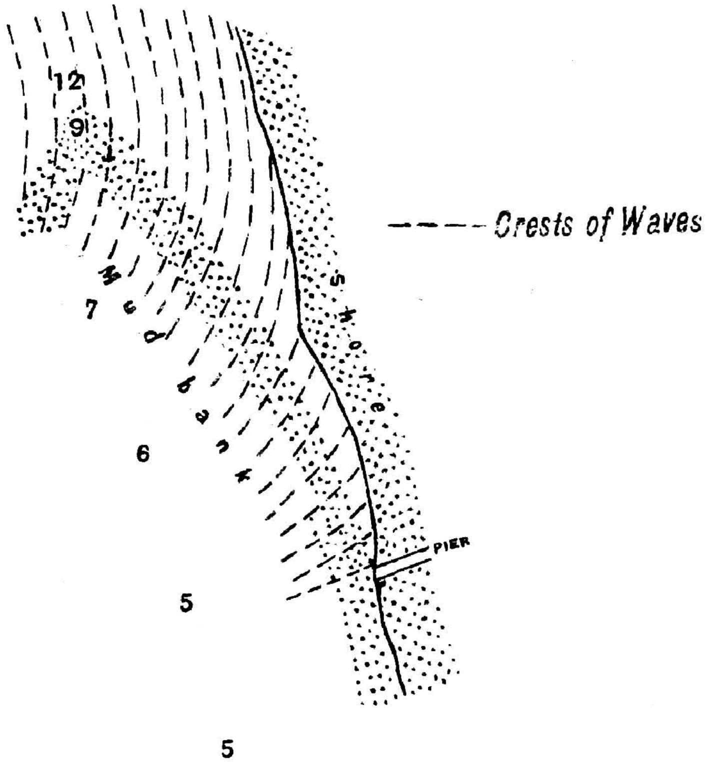

Fig. 1 N. end of Alleppy Mud bank

1 in = 400 yds (Soundings in feet)

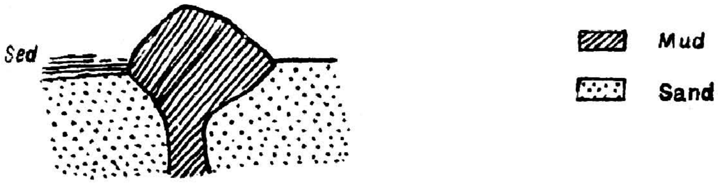

Fig. 2. Section of Mud Eruption at Alleppy

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CHAPTER IX

Extracts from the

TRAVANCORE STATE MANUAL,

Vol. I, Published 1906.

Note on the smooth water anchorages off the Malabar Coast.

CHAPTER IX

Smooth water Anchorages.—There are two anchorages on the Malabar Coast, known to mariners from early times. The bottom of these anchorages consists of a very fine, soft, unctuous mud which has over and over been supposed to act as a barrier against the force of the waves of the sea. Ships cannot only ride safely in these roads, but they can also sometimes take in fresh water alongside, the sea beneath them being so diluted with fresh water from inland sources. At times the smooth surface on one of the banks may be broken by huge bubble "cones" as they have been called, of water or mud from the sea-bed, and even roots and trunks are reported to have floated up with these ebullitions. Again the banks of mud are not fixed in position but move along the coast within ranges of some miles in extent; or one of them remains comparatively stationary while the other moves, and these movements do not take place year by year with the monsoons but continue over many years. Similar, though insignificant, patches of smooth water banks are found in various points along the Malabar Coast. But the best marked and the most generally known are those near Cochin and Alleppey. That near Cochin or the Narrakal Bank may be said to lie between Cochin and the Cranganore river 11¾ miles to the north. For many years its position has been about the middle of the range. The Alleppey bank ranges from a mile or two north of Alleppey to Poracaud, a distance of 12 to 15 miles. It is now at the southern end of this range, and indeed is often called the Poracaud mud-bank. The mud-banks lie close along the beach but extend some miles seaward presenting a more or less semi-circular or flat crescentic edge to the long rollers and tumbling waves of the monsoon weather.

Ordinarily, the sea is tolerably smooth, only rolling on the shore with more or less of a surf, and these patches are only to be distinguished by the soundings of mud below them. It is only a few days after the bursting of the monsoon, when the whole line is affected and the mud in these particular places stirred up, that the patches are distinguishable. Then the muddy waters calm down and remain so for the rest of the monsoon.

The mud itself is essentially characteristic and unique. It is of a decided dark green colour slightly tinged with brown, very fine in texture, very soft and oily feeling, altogether just like a very fine soft ointment or pomatum. After a time it dries and hardens, loses its oily feel and becomes harsh like ordinary mud. Its oily consistency has been proved beyond doubt; the specimens analysed have been found to give off, when subject to distillation, some brownish yellow oily matter lighter than water and looking not unlike petroleum. The muds also contain a considerable quantity of foraminiferal and infusorial remains.

Capt. Drury thus wrote on the origin of these banks:--

"The origin of this deposition of so large a quantity of mud in the open sea about two or three miles from the shore and so many miles from any bar or outlet from the backwater, has never been satisfactorily accounted for. From the circumstance of there being no natural outlet for the vast accumulation of waters which are poured down from the various mountain streams into the basin of the backwater nearer than thirty-six miles on either side, it is not improbable that there exists a subterraneous channel communication with the sea from the backwater through which the large quantity of mud is carried off and thrown up again by the sea in the form of a bank".

Mr. Crawford, for a long time Commercial Agent at Alleppey, was of the opinion that the perfect smoothness of the water in the roads and at the Alleppey beach was attributable not so much to the softness of the mud at the bottom as to "the existence of a subterranean passage or stream or a succession of them which, communicating with some of the rivers inland and the backwater, became more active after heavy rains particularly in the commencement of the monsoon than in the dry season, in carrying off the accumulating water and with it vast quantities of soft mud". He found that at the periods of deficient rain the mud-banks were less effective as anchorages. He also observed that after or during heavy rains the beach suddenly subsided, slightly at first but gradually as much as five feet, when a cone of mud suddenly appeared above the water, bursting and throwing up immense quantities of soft soapy mud and blue mud of considerable consistence in the form of boulders with fresh water, debris of vegetable matter decayed and in some cases, fresh and green.

Mr. Rhodes, the successor of Mr. Crawford, confirms the above observation and states that he has seen mud volcanoes

bursting up in the sea during the rainy season, which appeared "as if a barrel of oil had suddenly been started below the surface". He thinks that the mud thus formed is gradually floated away to the southward by the littoral current and fresh banks are formed whenever the hydraulic pressure of the inland backwater increases sufficiently to overcome the subterranean resistance of the stratum of the fluid mud which is formed at certain places; and as a further proof, he adduces the fact that the extent of the mud-bank at Alleppey increases and diminishes as the level of the inland water rises and falls, as was most observable in 1882*.

The range of the coast exhibiting the phenomena is about 92 miles long, tolerably straight, without any indentation giving the form of a bay except at the extreme ends, viz., at Quilon and Cranganur. There is no indication of a bay near Alleppey, the name 'bay' having perhaps been adopted from an imaginary bay of smooth water enclosed within the semicircle of breakers outside. The shore line is straight, low lying or only a few feet above sea level and made up of alluvial deposits and sand. Between Alleppey backwater and the sea there is no visible communication, the principal rivers that enter it flowing northwards behind the range of the mud-bank. To all appearance the flat lands of the coast are entirely recent alluvial deposits consisting of layers of sand and mud overgrown with vegetation. The lumps of blue clay described by Mr. Crawford as turned up in the cones of Alleppey, answer to the lumps of clay of the lower part of the Varkala cliffs already described. Mr. Crawford also describes his having passed through a crust of chocolate-coloured sandstone or a conglomerate mixture of the sandstone and lignite corresponding to certain rocks at Varkala.

* In regard to the formation of the bank, Mr. Philip Lake of the Geological Survey, in his note on the Mud-banks says:—"The chief point then in which I differ from previous observers is in considering that the Alleppey bank is formed not from the backwater mud but from an older river deposit found only at particular points along the coast. This would explain its non appearance at other points where the conditions seem equally favourable. With regard to the existence of subterranean channels, it may well be doubted whether any could exist in such unstable deposits as are found here".

It is clear that both the Alleppey and Narrakal banks have practically the same constitution, behave similarly and have the same accompaniments with the exception of the violent discharges of mud or oil which are confined to the Alleppey bank.

It has already been remarked that the mud of these banks is full of organic matter, and that it contains a sensible amount of oil, probably partly from the decomposition of organisms. The mud is easily stirred up on all seasons and never settles down into a uniformly compact deposit, but the upper stratum is in a greater state of liquidity than its lower depths. It occupies particular areas and within these well defined limits its movement is from north to south.

Regarding the water over the mud, Dr. King says :—

"It is only known to calm down during the S. W. monsoon. The calming of the anchorages does not take place until after the monsoon has commenced and there has been a stirring of the sea and mud. The quieting of the waters is intensified according to the amount of rainfall during the monsoon; but even if no rainfall, there is a certain amount of quiescence. The calmness continues throughout the monsoon, apparently without any fresh stirring up of the mud. In one locality at least, the water is subject at times to violent agitation through the bursting up of gigantic bubbles of water, mud or gas,—it is not quite clear which; and these features also appear to be intensified during heavy rainy weather in the monsoon periods. The water over the banks becomes considerably freshened even to the extent—as I was told by Mr. Crawford—of being drinkable; also according as the monsoon rains are light or heavy. At such times, also, the water gives off fetid odours, and the fish inhabiting it are killed off in large numbers; but whether owing to the freshening of the sea-water, or the exhibition of poisonous matter and vapour in the water, is not clear; perhaps this destruction of life may be due to both causes".

The soothing of the troubled waters of the sea must surely be due to the oily constitution of the mud. An experiment performed some time ago in the harbour of Peterhead, when a stream of oil was cast upon the heavy sea at the harbour's mouth with such success that vessels were enabled to run in with comparative ease, clearly proves this. Thus the action of oil on troubled waters is confirmed not only by tradition and anecdote but actual fact; but the long continuance of the quiescence without any fresh stirring up is not clearly accounted for. The amount of oil derived from the decomposition of the animal and

vegetable matter of the organisms in the mud would be hardly sufficient to account for the features exhibited; hence we must look to other sources for the oil and even for the continual supply of mud itself which is evidently carried away and distributed by littoral currents.

The consensus of opinion certainly leads to the conclusion that there is an underground discharge of water at any rate into the sea from the lagoon and river system behind the Alleppey-Poracaud coast during flood time, the inland waters being at a higher level than the sea. This passage of underground waters must, more particularly during heavy rains, force out large quantities of the mud on which the Alleppey-Poracaud land rests like a floating bog, as it were, elastic and capable of yielding to pressure or exerting pressure by its own weight; while a continuous stream of the same oil and mud may be kept up under the lower pressure of the ordinary backwater level. In the monsoon time the heavy floods, which however, occur at long intervals, cause great discharges of mud, oil, and gases, and at such times new banks might be formed, the old ones being distributed down the coast by littoral currents and finally dissipated into the open sea.

The presence of petroleum has to be accounted for by the fact that besides the alluvial deposits large lumps of clay or compact mud more or less decayed, and vegetable remains are brought to the surface during the prevalence of the violent ebullitions. Such clays are met with in the Varkala deposits associated with lignite beds, in which occur trunks and roots of trees in every stage of decay. It is probable that the Varkala deposits may extend north under the Alleppey-Poracaud alluvium and even again at Narrakal where also fragments of similar clays are thrown up by the sea; and that it is in these deposits as being deeper seated, older and ligniferous that the earth-oil is generated.

Thus according to Dr. King, the mud-banks, their smoothening influence, and their position within certain ranges of the coast, may be entirely due to the following causes.—

1. The discharge of mud from under the lands of Alleppey, Poracaud and Narrakal, being effected by the percolation or underground passage of lagoon water into the sea.

2. The presence of oily matter in this mud, derived perhaps in part from the decomposition of organisms but principally from the distillation of oil in subjacent ligniferous deposits belonging presumably to the Varkala strata.

3. The action of littoral currents which, slowly and through long periods of years, carry the mud down the coast to certain points whence it is dissipated seawards,—by the Quilon river at Narrakal, and at Poracaud because it is there beyond the range of replacement.

CHAPTER X

Extracts from the

COCHIN STATE RECORDS

from 1888 onwards, referring to the position of

the Narakkal Mud Bank.

CHAPTER X

Extracts from the Administration Report of 1064 (1888—1889).

"The warehouses at Narrakal realised no rent during the year under report from the fact that the landing and shipping of goods were greatly obstructed by a large accumulation of mud on the foreshore".

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"The anchoring buoy was scraped and painted in the month of April and the bearings rectified by an Azimuth compass. In the Port Officer's opinion this buoy will have to be removed further south owing to the mud-bank having shifted, which renders the old position of the buoy untenable".

Extracts from the Administration Report of 1065 (1889—1890).

"The anchoring buoy had to be removed further south owing to the mud-bank having shifted—vide para 278 of the Administration Report of 1064. This work was carried out on the 20th February 1890 under the Port Officer's personal supervision, with the aid of the S. S. "Chindwara" which was kindly placed at his disposal by the B. I. S. N. Company. The buoy was placed half a mile to the southward of its former position with the following bearings from seaward (Magnetic). Narrakal flagstaff N. 71° 30'E. Cruz Milagre Gap, S. 49° 30' E., Cochin Light House S. 35° 30'. E. The buoy (painted red) was placed in 18 feet low water spring tide and about 2¼ miles from the shore. The Port Officer reports that the best anchorage for the S. W. monsoon is to the south and west of the buoy in from 4 to 4½ fathoms soft mud".

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"The S. W. monsoon was ushered in very mildly in 1890 and the wind was well to the westward. Some heavy squalls in June brought down the mud-bank further south than it had ever reached, so as to enable boats to work on the beach even as far south as Malipuram, but the smooth water on the beach was as

erratic as the mud which has a tendency to settle further south ward every year".

Extract from the Administration Report of 1066 (1890--1891).

"The working season, viz., the south-west monsoon began early at the Port of Narrakal, owing to the early advent of the monsoon, which was well southerly. It agitated the soft mud-bank and rendered landing and shipping operations practicable, but a break happening in June brought in the mud, which formed a bank well out to seaward even to the south of the southern jetty, causing very great inconvenience to the landing and shipping operations. The mud-bank having this year shifted further south, the Port of Malipuram was utilised for landing and shipping a major part of the goods, but the erratic character of the mud rendered any permanency of a smooth beach impossible at Malipuram. On the whole, the work of the Port was very much retarded by the large accretions of mud rendering the hard beach unapproachable except at high water spring tides".

Extract from the Administration Report of 1067 (1891—1892).

"The mud-bank, which had last year shifted to the southward was found, on examination, to extend even to the southward of the Port of Malipuram, where all landing and shipping operations had to be done during the season, as the mud-bank off the Port of Narrakal proper, extended far out from the southern jetty and prevented all work from being carried on there".

Extract from the Administration Report of 1068 (1892—1893).

"The position of the great mud-flat remains unchanged. It is semi-circular in form and extends three or four miles seaward, with its centre off Narrakal, its southern arm near Malipuram and its northern limit about three miles northward. At Narrakal smooth water prevailed during the whole season, but the beach approach being very shallow, cargo-boats drawing five feet of water could not come closer than two hundred yards. Cargo was landed on the beach, sometimes at Malipuram, at other times further to the north".

Report No. 13/73, dated 27th June 1892, from J. E. Winckle Master Attendant of Narrakal Port, submitted to the Diwan of Cochin.

"The Port of Narrákal must be considered now as in a state of transition—We will therefore have to carefully observe the present state of the mud-bank which afford smooth anchorage in the S. W. monsoon, it being erratic in character. For the last two monsoons Narrakal as a port for smooth water anchorage, and for landing and shipping operations has been practically useless, all the work having been done at Malipuram owing to the mud having formed and solidified a long way from the shore proper at Narrakal, rendering all approaches by boats to the hard beach, or to either of the southern or northern jetties perfectly impracticable. These unsurmountable disadvantages on shore, together with the smooth water anchorage having shifted further south, dissuades me from recommending at present that the light at Narrakal to be substituted by a new one".

Extract from the Administration Report of 1069 (1893—1894).

"The great mud-flat advanced a quarter of a mile to the north, its centre being also east of Narrakal and its southern limit 500 yards north of the flagstaff at Malipuram. Its length and breadth remained the same. The sea is receding from this part of the coast and the pier at Narrakal remains high and dry even during spring tides. This then, was the exact position of the mud-bank in the year beginning with 15th August 1893 to the 15th of August 1894".

Extract from the Administration Report of 1070 (1894—1895).

"The position of this great and historical mud-bank remains unchanged, its centre continues abreast of Narrakal and its southern limit 500 yards north of Malipuram".

Extract from the Administration Report of 1071 (1895—1896).

"The position of this historical mud-bank continues unchanged, its centre lies off the Narrakal flagstaff extending north

and south about 2½ miles (*i. e.* to the south within 250 yards of the Malipuram landing place)".

Extract from the Administration Report of 1072 (1896—1897).

"The position of the Narrakal mud-bank remained unchanged and the foreshore in front of the flagstaff was becoming hardened by sand mixing with the mud. Soundings taken, showed a more or less solid foundation".

Extract from the Administration Report of 1078 (1902—1903).

"Owing to the mud-bank off Narrakal having extended southward and westward, the anchorage has been shifted southward from time to time and Narrakal abandoned as a Port".

CHAPTER XI

The personal recollections of G. H. DAVEY, Esq.

of Rocky Ridge, Kottayam, Travancore,

sometime Merchant of Travancore,

narrated in letter form, 1928 and 1937.

Relating chiefly to the Mud Bank at Alleppey.

CHAPTER XI

Rocky Ridge,
Kottayam,
Travancore,
S. India,
14th August 1928.

My dear Bristow,

xx xx xx

The St. Georges were here to tiffin yesterday and told me you had gone off to Alleppey to see what they said was a very wonderful phenomenon of the mud being all around the pier. I have not seen the present instance, but if, as I understood from them, the authorities say that such a thing has never happened before, they are talking nonsense. It has happened several times before and is usually the immediate result of heavy weather at sea. The mud gets churned up thick like butter and nothing will float in it. It happened also many years ago at Narrakal to the north of Cochin and several boatloads of rice sank and after that the monsoon port was shifted to Malipuram.

At Alleppey also I have known of sea boats laden with rice sinking and a diver being got from Cochin marked one of these that belonged to me and undertook to save me the boat. He went off to Cochin to bring other men to help him to remove the rice bags but on his return not a vestige either of boat or rice was to be found—the whole had apparently gone below in liquid mud. Old Capt. Crawford, Port Officer of Alleppey for 30 years odd, prior to 1878, told me weird stories of the mud-bank. He had tried to fathom its depth with a series of rods screwed together but could not get bottom.

In 1903, I remember the mud oozing up in little volcanoes all around the old pier and stumps of trees coming up. One enormous one with roots of 30 to 40 feet diameter right near the pier. Old Vernide, the acting Port Officer and I tried to get this pulled on shore by elephants, bud did not succeed. I have seen the pier cut off entirely with a full ¼ mile of thick mud to seaward and little islands of mud with birds sitting on them.

Further, when I sank a bore in our yard at Alleppey to 316 ft., I got nothing but thin layers of sand and small shells varying in thickness from 1 to 2 feet thick and very hard and then 6 to 7 feet of liquid blue clay and then another layer of sand and shell and so on. I only began to get pebbles at 316 feet and then unfortunately broke my apparatus and had to stop, and this shows I believe that Alleppey and the neck of land to Cochin are really the result of centuries of the discharge of the rivers mixing with the sea and forming the backwaters. Also when there has been unusually heavy rain and the weight of water in the backwaters suddenly increased, great balls of mud have come ashore with the action of the tides and rolled up on the beach. This, I imagine, indicates that some of these liquid sub-strata are moved by the weight in the backwaters.

I don't know if all this will be of interest to you, but thought you might like to know some of the phenomena that I have personally witnessed.

With kind regards,

Yours sincerely,

(Sd.) Gerald H. Davey.

12th August 1937.

Rocky Rridge,
Kottayam,
Travancore, S. India.

* * * * * * *

Now as regards the mud-bank, I have been thinking over your letter carefully with a view to giving you any information that may possibly be of service to you. When I landed at Alleppey in January 1885 the mud-bank was there, and nearly all cargo was carried by headload right down to the boats on the beach. The old pier was almost high and dry, and was seldom used except to land rice or an occasional heavy package, there being a crane at the further end capable of lifting 30 cwts. The sea on the beach was absolutely smooth water. I was told by Mr. Darragh that the mud-bank had been there then for several years, and that the native merchants, never making use of the

pier, had petitioned the Government not to charge pier toll on goods loaded on the beach and Government had agreed to this.

I was in Alleppey during the monsoons of 1885 and 1886 and during those years when there was bad weather the place looked like a lake with a fringe of heavy seas and waves about a mile and a half to 2 miles out. In continuous bad weather this fringe would come nearer and at times the lake would appear to be moving slightly to the north. Small coasting steamers as there were running on the coast, appeared to come inside the fringe and anchor presumably in liquid mud. In 1885 a small barque called the "Papa Olivari" arrived just as the monsoon started and anchored just inside the fringe. We, (James Darragh) had to load her with a full cargo of copra for Marseilles. She was there for some 30 days or so, as the loading was very slow owing to the rains, and she several times had to kedge herself northward as the fringe of waves approached nearer in heavy weather, but we eventually finished her loading and she was lucky in getting a strong land wind a few days afterwards and got away safely and reached Marseilles.

1887 and 1888 monsoons, I was away at Quilon and returned to Alleppey in October 1888. The mud-bank was still there. In 1889 we had a ship called the "Suffolk", (which Darragh had bought), coming up from Colombo with coal from Australia. She was sighted off Quilon and that same night the monsoon burst and she was forced to run south of the Equator and only arrived at Alleppey in July. She anchored in the mud and we commenced her discharge immediately, and at that time the sea had receded and left the old pier high and dry. I had to rig up a temporary affair of timber on the beach to enable us to ship the pipes and hogsheads of cocoanut oil which had to be brought down from Cochin by backwater, as it was impossible to send the ship there to load. Eventually we completed the loading, but unfortunately, she could not get a favourable land wind to enable her to get away and the Captain got alarmed as the mud was getting thicker and thicker all round the ship. The Captain and I went on board a small B. T. boat the "Asia" and tried to persuade the skipper to tow the "Suffolk" off the mud and I offered him Rs. 500 to do this, but he demanded Rs. 1,000. This

we refused to pay and it's nice to know that the skipper got hauled over the coals severely by Mackinnon Mackenzie and Co., when they heard about it.

We had therefore, to get her off by other means and we got a large kedge anchor which was lying outside the Customs House and took this out in a large cargo boat and dropped it in position bringing a long cable over the top of the main thwart of the cargo boat and then round the stern of the "Suffolk" to the capstan. We also chartered 12 large fishing boats, with 12 rowers in each, and went off at 3 a. m. the next day and started to work. It was a day I have good reason to remember for I took about 100 coolies on board with me and these were to man the capstan and also get the ship's anchor up, whilst the crew set the sails. The ship was over 30 years of age and to get the anchor up had an antiquated winch which worked like a fire engine of those days bringing up one link of the anchor chain with each movement up and down. It was arranged that I should take charge of the fishing boats who were all to join in towing the ship's head round, and also to look after the working of the anchor winch, whilst the Captain would look after the working of the capstan and give the signal to the man in the cargo boat when to sever the cable, as he had been instructed to do, and had a large hatchet for the purpose.

Well, I began to think she would never budge when suddenly the fishing boats towing her head evidently began to feel that she was beginning to do so, and set up a hell of a yell! Next I knew was the Captain swearing like blazes that the anchor was not coming up fast enough, and next the cable being cut and flying towards the ship as if it would strike us. I rushed to the winch and personally in my excitement caught hold of it, and when it was rising, I found a ring on the third finger of my right hand had got caught in a notch or nail in the handle, and I was taken up and my finger stripped clean to the bone as far as the knuckle, the ring fortunately breaking.

The Captain fortunately had his wife on board and I was taken down to the cabin, drank two bottles of beer, while Mrs. Card dressed my finger with cotton wool and St. Jacob's oil and bandaged it, etc., and when I went over the ship's side to get

into the boat that was being towed alongside with old Sayter, (an East Indian who had himself been a sailor and was the man who was put in charge of cutting the cable), we were out of sight of land and even the Alleppey light-house was not to be seen! We landed on the Alleppey beach that night at 7 p. m. and except for the two bottles of beer on board I had had nothing to eat or drink since the previous night—but I felt so glad at having got the "Suffolk" off, and my finger, by that time, had ceased to pain, that instead of going off to the hospital to get it attended to, I felt it was better left alone, and so I did, and my finger has healed so that no one would ever dream that it had ever been hurt! So you see I have reason to know the mud-bank.

In 1890, the mud-bank moved considerably to the north of Alleppey. In 1891, 1892 and 1893, I was away at Quilon; in 1894 I went home for my first leave, returning to Quilon in January 1895, and shortly after, I came back to Alleppey to take charge of the business again as Smail had to go to New York. By that time the mud-bank had gone south several miles from Alleppey and was still there in 1896.

In 1897 (in April or May, I think) was the earthquake in Calcutta, and that night I was returning from Quilon in a small third class Wallum and had gone to sleep on my bed on the floor of the boat, when I woke suddenly to find the D. P. W. lantern which had been on the thwart of the boat had fallen on to me and set the bedding on fire, and the boat was pitching about, and the boatmen in a great state of panic. I got the bedding overboard before the thatched roof of the boat caught fire, and then began questioning the men, but all I could get out of them was that a tremendous wave had come and they were powerless. It was just about 1 a. m. and we were just entering the further end of the Kayencollam lake near Airenthengoo, and it was a beautiful moonlight night and I could not imagine what had happened. Only the following evening on arrival at Alleppey was I enlightened, where everyone was enquiring where I was during the earthquake. It appears that everyone there was awakened and rushed outside their bungalows and many walls and buildings were cracked; a large porch in front of the newly constructed Court House fell down, the walls of old Darragh's bungalow at

the beach, where I was living, were cracked, and I had to build buttresses to hold them together ; besides, considerable other damage in the town was done. I mention all this because you refer to earthquakes in your letter.

In June of that year, I left Madras for South Africa, so was not in Alleppey that monsoon, but it was an exceedingly severe one, the mud-bank being broken up entirely, and the sea encroaching and cutting away some thousands of cocoanuts to the south and breaching the road near the hospital.

In 1898 I was at home again to sign my first partnership agreement, during the monsoon, but so far as I can now recall the mud-bank that year and also 1899/1901 and 1902 remained south, near Trichnapuzha, close to the northern end of the Kayencollam Lake. I went home early in 1902 and returned in 1903 and it was that year when old Vernide, afterwards the Magistrate, and Commissioner of the Cardamon Hills was the acting Port Officer at Alleppey and the mud came back off Alleppey and the things happened as related in my letter to you of 14th August 1928.

Now before attempting to answer your queries about that letter, I should like to tell you, in case you may not have heard of it before, that to the south of Karamudi (½ a mile from Ambolapuzha) the canal to Quilon passes through a large area of marsh land in which there is no vegetation except a kind of Bull-rush. This extends almost the whole distance to the Lock of Thottapulli, and east and west, the area must be a considerable number of square miles in extent, and the ancient traditions associated with this which I heard 50 years ago are that the whole of this area is a submerged forest that sank suddenly, and that what soil there is, is so saltish that nothing will grow in it.

Some years before I arrived in Travancore, I heard that T. Rama Row, then Diwan Peishkar of Kottayam and afterwards in 1887 Diwan of Travancore, had obtained a large concession of this land from the Government and spent large sums in trying to grow cocoanuts on it, but it had proved an absolute failure. There were still signs of these attempts when I first saw the place in 1885. I do not suppose that I should have thought much more about this tradition of the sunken Forest had it not

been for the fact that when the Government started to deepen the waterway (about 1905/1908 possibly) they found the whole bed of the canal or waterway a mass of enormous tree stumps with roots and they had to get cranes and tackle to haul these up and they were dragged to the sides on to the banks—the wood and roots were particularly hard and showed every sign of having been under water for years. I had several bits of these formerly at Alleppey which I collected from the banks myself—they (the D. P. W.) sold the stumps and roots by auction I believe.

One other point that may have a possible bearing on all this is: in the days when the Dutch were at Cochin and Tangacherry (Quilon) they joined the Rajah (then called the Rajah of Quilon and afterwards of Travancore) and declared war against the Rajas of Kayancolam and Ambalapuzha (you will find reference to this in the Travancore State Manual) and were victorious—according to repute, the Raja of Kayancolam said:—

"You may take my country but you shall not enjoy my paddy fields." and he is said to have gathered a large number of men to cut through the sands on the west and let the sea in.

There is still the Kayancolam Bar which opens I believe whenever the lake gets too full of water and though very shallow one still sees fishing boats go through it. It does not take a great deal of imagination to believe that all this is true, and that in former years what is now called the Kayancolam Lake was then fine paddy fields with the river from Trichnapuzha (the Atchencoil River I believe) running down the centre and eventually discharging at Chowrah into the large lake which has its outlet into the sea at the Niendacary Bar—certain it is that in the olden days the Chinese used to sail right into this lake, and even in my time we landed all the Quilon Mill Machinery and also the Poonalur Paper Mills Machinery in Cochin and Alleppey lighters that sailed right through the bar and up to the Cotton Mills, landing 4 miles away. The rapid manner in which that lake has been silting up certainly would seem to indicate that the quantity of the discharge of water has been reduced if my idea of the matter is correct.

And now in regard to your queries.

No. 1. The Static Head.—You must understand first of all that the methods I employed were absolutely amateurish. I had never any experience of how to sink a pipe into the earth. What I did was to sink a 4" pipe in the centre of an existing well in the Factory Premises at Alleppey. The depth of the well to the water was about 14 feet. By weighting the pipe at the top end by means of wooden clamps fixed to it so as to form a platform on which to place the weights, I managed to force the pipe downwards; the interior contents were removed by means of a jumper with a ball valve fixed below. When I came on to hard substances I removed the jumper and used a crowbar until the hard stuff was broken up sufficiently to be removed by the jumper. I had no idea of using a water jet which would possibly have greatly facilitated the sinking. At times, when we got on to hard layers, the progress was exceedingly slow and laborious, but at others the pipe would descend rapidly through almost blue liquid clay. At times I remember the pipe filling almost to the top during the night with water and liquid clay, as if we were getting on to an artesian spring, which was really the object of my sinking the pipe as I wanted to get water (fresh) for the Factory works of washing saltish coir yarn and dyeing.

2. The various alternate layers of hard conglomerate substances certainly extended almost the whole 300 feet down, though the mud or clay was much denser the deeper we got, and we could push the contents of the jumper in one solid mass out from the bottom. I had several rolls of this that looked like marble columns, which I dried on boards in my office. I found afterwards that when dry they burnt easily.

The places where the so-called volcanoes appeared were all within a quarter of a mile from the beach, I should say, and the depth of water would be about 15 feet, in ordinary times, but *then* the whole was liquid mud.

3. I know of no literature on the subject, though I do remember that John Rhode (then the Master Attendant of the Port) wrote a paper on the subject in 1886 which I read at the time, but I don't think there was much else in it than a theory of his that there was a possibility of Alleppey being washed into the sea, as the place had nothing but mud below it.

4. There is no doubt in my mind that the earthquake of 1897 had a great effect on the mud-bank, and caused the severe inroads made by the sea that year.

Why I have especially written about the sunken forest is because the tree stumps we saw coming up in the mud in 1903 were so similar in appearance to those that were found in the waterway when they deepened it.

* * * * *

Yours very sincerely,
(Signed) GERALD H. DAVEY.

CHAPTER XII

Various reports, and correspondence
with the Geological Survey of India,
in reference to the earthquake of January 1934.

CHAPTER XII

I

From the Executive Engineer, Cochin Harbour Division, To the Harbour Engineer-in-Chief to Government, Cochin, No. 511, dated 25th January 1934.

Ref: Your No. 102/34, dated 18th January 1934.

At 2. 45 on the afternoon of Monday, the 15th instant, the Pipeline Engineer sent me a chit asking if any weather report had been received, as conditions outside were very bad and there was an exceptional swell. Later, conditions became worse and at 4. 20 p. m. it was decided to stop dredging and pump water. At that time the dredger was in No. 1 cut on the north side of the channel, having shifted to that cut from No. 2 at 1 p. m. On Monday, the wind was W. S. W. at 11. 30, S. W. at 2. 30 p. m. and S. S. W. at 4 p. m. and 5. 30 p. m. The ebb tide continued until 8 p. m. The sea continued to be rough throughout the evening and the following morning, and at 2 a. m. on Tuesday the rivets connecting the socket on clam pontoon No. 25 at the joint between pontoons Nos. 13 and 25 sheared, and the line parted. Check and preventor wires were removed, and the clam pontoon No. 25 and the terminal pontoon to which it was connected were hauled clear. Clam No. 25 being useless, was then disconnected from the terminal pontoon, the intention being to connect the terminal pontoon to clam pontoon No. 13. It was found however that a number of the rivets on the socket joint on the terminal had been sheared, necessitating repairs in the inner harbour.

Meanwhile, (at 2. 30 a. m.) the port bat of the overhung pipe at the stern of the dredger broke, and the joint burst open. In endeavouring to get things into position again, the ship's derrick broke. The overhung pipe was eventually reslung, but damage at stern bats could not be repaired without disconnecting the line at the 50 ft. tubular, which had later to be taken inside to have a new pin fitted on underside of gimbal ring.

Mr. Lamont says he had never seen worse conditions at the

stern of the dredger from 6 p. m. on Monday onwards, and the damage to the line generally was the result of the sustained hammering it received. At the time the actual breaks occurred, the conditions were no worse than they had been for hours previously, if anything, they may have been slightly better.

I have heard no reports of an earthquake shock locally other than that felt on the afternoon of Monday.

II

From the Harbour Engineer-in-Chief to Government, Ernakulam P. O., To the Secretary to the Government of Madras, Finance (Marine) Department, No. 158/34—1, dated 26th January 1934.

Earthquake on Monday, the 15th January 1934.

With reference to the earthquake which occurred in India on 15th instant, I have the honour to inform Government that although there are no results visible at Cochin so far, there was an exceptional disturbance at sea on that day which rather seriously affected the maintenance dredging work and damaged some of the pontoons of the pipeline and other gear, whilst the dredger was working on the outer bar.

2. I enclose a report from the Executive Engineer which describes what happened during the day and night. I visited the dredger at 5. 30 p. m. on 15th, having received no intimation of an earthquake elsewhere, but convinced that a very unusual disturbance was prevailing. I left the ship at 7 p. m. apprehensive of trouble during the night and on the journey back to harbour my launch "Dorothea" was caught in a very severe roll from the southward and nearly capsized on several occasions. This occurred at 7. 20 p. m..

3. I awoke at 2 a. m. on 16th with the impression that there had been a definite tremor in the building. On looking at the dredger and pipeline through the glasses I could see that the line was intact as a whole though the searchlights were playing on the end pontoons. Although there was no wind the sea was still high and I kept the plant under scrutiny until 4 a. m. when the conditions seemed better. I had requested the officers

of the dredger to send a special message if anything serious occurred.

4. All this happened without my having had any intimation of an earthquake elsewhere, but after news came of this, a few of my staff and others said that they felt a slight giddiness at about 2-15 p. m. on 15th "as if they or the tables were rocking." In view of the fact that these buildings are on a somewhat compressible subsoil, I am having careful levels taken to see if any special subsidence took place. There has been a slight, and immaterial, subsidence of all of them since erection. A further report will be made about this.

5. It is suggested that the above report may be of interest to the meteorological and perhaps other authorities. A few spare copies are therefore attached.

III

From the Harbour Engineer-in-Chief to Government, Ernakulam P. O., To the Secretary to Government, Finance (Marine) Department, Madras, No. 158/34-2, dated 5th February 1934.

Earthquake on 15th January 1934—Subsidence of the new buildings on the reclamation.

In continuation of my No. 158/34-1, dated 26th January 1934, I have the honour to inform Government that so far as can be ascertained, this office and quarters and the other new buildings on the reclamation subsided about three-quarters of an inch as a result of the earthquake on 15th January 1934. For the most part the subsidence was even, but the quarters of the Mechanical Superintendent sunk chiefly at the southern end.

2. I am of opinion that the whole of the subsoil for a depth of at least 20 feet was affected and settled down as well as the buildings above.

IV

From the Administrative Officer and Harbour Engineer-in-Chief, Cochin Harbour, to the Director, Geological Survey of India, 27, Chowringhee Road, Calcutta, No. 3157/37-2, dated 7th August 1937.

I have the honour to forward for your information, copy of

reports made by me to the Government of Madras on the 26th January 1934 and on the 5th February 1934 explaining how the earthquake on Monday the 15th January 1934 affected the Port of Cochin so far as could be seen at that time.

2. Although an earthquake was undoubtedly felt to a minor degree at Cochin and Ernakulam and although the dredging operations were seriously affected by disturbed seas during the evening and night of the 15th of January, we did not notice at the time any physical changes worth mentioning except perhaps that there was reported to have been a somewhat turbulent rising of water in some of the wells at Ernakulam.

3. During 1935 and 1936 however, and possibly before then there was either a travel south of mud-banks or a rising of the sea bed to the north of Cochin Harbour. There were very poor rainfalls in 1934 and 1935 and it was first assumed that the fluvial discharge from the backwaters, being much less than in previous years, had failed to keep back the northern mud-banks which otherwise have a tendency to move south.

4. There have been signs, however, during this monsoon that the rainfall may not have been the cause of the accretion of the mud-banks nor for their movement southwards, and it is now desired to ascertain what has caused the recent change in the height and position of the well-known mud-banks north of Cochin which, it was believed, had been fairly stable for at least a century.

5. I shall be glad therefore if you will kindly inform me:—

(1) if you have had any evidence elsewhere of any rising of the sea bottom conceivably caused by an earthquake on 15th January 1934,

(2) if a copy of all the evidence on the subject of the earthquake has been collected, and whether a copy can be sent to me for information and

(3) if you are in possession of any evidence other than this particular earthquake which might give us a clue to possible results at Cochin.

6. I may add that the mud-banks north of Cochin are very easily moved from the bottom, and though they do travel up and

down the coast to a small extent they have always hitherto returned to their normal resting place at Narrakal and Malipuram in a short time,—that is, so far as is known at present.

V

From the Director, Geological Survey of India, Calcutta to the Administrative Officer and Harbour Engineer-in-Chief, Cochin Harbour House, Ernakulam P. O., No. 5002/1816 (1), dated 19th August 1937.

I have the honour to acknowledge your letter No. 3157/37-2, dated the 7th August 1937, with enclosures.

It is the opinion of the officers of this Department, who investigated the North Bihar earthquake of January 15th, 1934, that no shock connected with this earthquake was felt down the West Coast of India. Moreover, no phenomena similar to those described by you were perceived on the coast of the Bay of Bengal, though this is situated very much closer to the epicentre of the earthquake than Cochin. It is therefore thought that such phenomena as were observed at Cochin were unconnected with the North Bihar earthquake, and the fact that they happened to occur soon after this earthquake must be regarded as a coincidence.

A memoir on the North Bihar earthquake is nearing completion, and it is expected that it will be published during 1938. It will contain all the evidence collected in connection with this earthquake.

It is well known that tidal waves may be caused by earthquakes, but in such cases the epicentre has been beneath the sea or near the coast, and not far inland as in the case of the North Bihar earthquake.

I regret that I am unable to suggest any cause for the phenomena observed at Cochin.

VI

From the Administrative Officer and Harbour Engineer-in-Chief, Cochin Harbour, to the Director, Geological Survey of India, Calcutta, No. 3398 A/37-1 dated 25th August 1937.

I have the honour to acknowledge with thanks the receipt of your letter of the 19th instant, and shall be pleased to have a

copy of the memoir on the North Bihar earthquake when it is published. Although, of course, every respect must be paid to the views of the officers of your Department who investigated the earthquake of January 15, 1934, there can be no doubt that the state of the sea which I and my officers witnessed at Cochin was phenomenal for any month of the year but especially so *for the month of January* which is the one reliable month of the year.

(2) Moreover, in the 1897 earthquake at Calcutta, the shock was felt along the Malabar Coast resulting in damage at the Port of Alleppey and the creation of a tidal wave, even in the backwaters far south of Cochin. I have the written evidence of one who is still in this country giving his experience of that event. I enclose a copy of his statement which may be of interest to you. The description of the effects of that tidal wave corresponds with the much more violent wave which we observed on January 15, 1934, and I cannot believe that there were two coincidences of the same sort following two earthquakes.

VII

From Dr. A. M. Heron, D. Sc., F. G. S., F. R. G. S., F. R. S. E., Director, Geological Survey of India, Calcutta to the Administrative Officer and Harbour Engineer-in-Chief, Cochin Harbour House, Ernakulam P.O. No. 5284/1816 (1), dated 6th September 1937.

I have the honour to acknowledge with many thanks the receipt of your letter No. 3398 A/37-1, of the 25th August 1937, and the very interesting account of the 1897 earthquake by Mr. G. H. Davey.

No. 3706/37-1, dated 11th September 1937.

Copy of correspondence to Mr. G. H. Davey for information.

Administrative Officer
and Harbour Engineer-in-Chief.

CHAPTER XIII

EXTRACTS FROM THE

History of Proposals, Cochin Harbour Development, in which the mud banks at Alleppey or Cochin are referred to by eminent Engineers.

(1) Pages 124-5. (2) Pages 137-8. (3) Pages 151-2.

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(1) By Col. R. H. SANKEY, R. E., Chief Engineer, P. W. D., Madras, 1881.

(2) By GEORGE ROBERTSON, M. Inst. C. E., (1871).

(3) By J. R. BELL, (1913).

CHAPTER XIII

REPORT ON THE COCHIN HARBOUR.

In compliance with the decision of Government conveyed in G.O. of 27th December 1880, No. 2943 W., we, the undersigned, inspected the Cochin Harbour on the 4th and 5th instant, and on the latter date had the advantage of a very complete discussion of the several points at issue with the Chamber of Commerce, several of the leading native merchants being also present on the occasion.

** ** **

49. We took advantage of our visit to Cochin to inspect the singular mud-bank at Narrakal, situated some six miles to the north, and which for the last few years has been used by the merchants for shipping and landing goods throughout the monsoon.

50. There is backwater all the way to within a quarter of a mile of Narrakal, where the Cochin Government have cut a boat canal across the sands-pit separating it from the sea, and constructed covered passage with tramway from this close up to the beach, as also a small landing pier. The very serviceable condition of this latter work after three years wear and tear, shows that at least in that period there have been no heavy seas at this point.

51. The bank consisting of the very finest mud (of a greenish-black colour and very unctuous to the touch) seems so far as can be ascertained to extend about three miles along the shore from south to north, and four and half miles out to sea. It has not apparently shifted its position as seems to have been the case with other similar banks notably that which though known to have been at Alleppey some twenty years ago, has apparently moved seven miles south to Porcad, and is still believed to be progressing gradually to the south.

52. The effect of the bank on the portion of sea covering it is singular, as at the first burst of the monsoon there is said to be the same surf as in other parts of the coast; the water is

discoloured and dark with the churned up mud. But after this stage has passed this seems to settle down and becomes clear like the rest of the neighbouring sea. Some persons consider the surface has an oily look at this time, and others that air bubbles, stems and branches of apparently submerged trees rise to the surface, etc., but of none of these statements is there any distinct proof.

53. What, however, appears certain is, that the full characteristics of this tract in providing a perfectly quiet anchorage during the monsoon are not fully developed till the monsoon has sufficiently advanced to render the water in the backwater on the land side quite fresh, and that during this period the water on the bank out to sea is also so fresh, as to lead to the conclusion that such water at this time rises from the bottom under pressure.

54. The effects, however, are that the monsoon swell gradually subsides over the outer limits of the bank, and vessels are thus enabled to run into comparatively quiet still water at the height of the monsoon, thus providing Cochin with an unrivalled harbour during this period. So far as can be ascertained, no surf breaks along the margins of the bank; the seas merely die away.

55. There can of course be no question that there are a number of serious drawbacks to trade conducted in this manner, and that merchants suffer considerably by losses of goods exposed in the canal boats, and by fraud and carelessness on the part of the boatmen, but the fact remains that they are able to carry on trade at this period when all other West Coast ports (except Porcad) are closed.

56. As considerable interest attaches to the conditions under which the mud-banks alluded to exist on the coast, it is to be hoped that Mr. W. King, Assistant Superintendent, Geological Survey of India, who joined us, and secured some specimens of the mud for analysis, may be enabled to follow up the enquiry.

** ** **

R. H. Sankey, Colonel, R. E.,
Chief Engineer, Public Works Department.

Madras,
29th February 1881.

J. H. Taylor Lieutenant, R. N. R.,
Master Attendant.

Report to the Government of India on Narrakal by George Robertson, Fellow of the Royal Society of Edinburgh; Member of the Institution of Civil Engineers; past President of the Royal Scottish Society of Arts (1871).

On the 28th February I visited the remarkable mud-bank of Narrakal in the pearl fishery steamer "Margaret Northcote". The Diwan of Cochin was on board, and also the Master Attendants of Madras, Cocanada, Cochin and Tuticorin; so that nautical advice was not wanting. This curious and valuable anchorage was fully reported on and surveyed by Captain Castor, when he was at Cochin. From his reports, and from what others told me, there cannot be the slightest doubt as to the tranquillizing effects of the mud during stormy weather, and the value of Narrakal as a natural harbour of refuge during the monsoon.

We sent a diver down for specimens of the mud, which is of a dark green colour, and of a peculiarly greasy character. It has been analysed at Madras. When we were at Narrakal, though there was a considerable swell on the sea, yet the weather was too fine to develop the peculiarities of the bank. There was, however, sufficient surf on the coast elsewhere to show the marked difference at Narrakal, where, for some miles, the surf ceased, and there was not a ripple at the water's edge.

The whole phenomena connected with the mud-banks, both here and at Alleppey, are well worthy of careful scientific investigation. There are many places on the coast of India, where the presence of mud has a quieting effect on the surf, but none so remarkable as these two spots; both of them, be it remarked, in the vicinity of the same backwater, and far from any great silt-bearing river.

Several theories have been raised in connection with these mud-banks; but I consider that, at present, there are not sufficient scientific data upon which to found a true theory as to the origin of the banks, and the connection that is supposed to exist between them and the adjoining backwater.

The special point upon which the Government of India

have asked my opinion in connection with Narrakal and Alleppey, is the possibility of taking advantage of such localities, and opening out communications between them and the backwaters.

With regard to taking advantage of the localities, as two natural harbours of refuge in the vicinity of the close harbour of Cochin, I consider the banks most valuable additions to that port, and amongst the most cogent reasons for its improvement. No other harbour in the world has such adjuncts. But, with regard to opening out direct communication between Narrakal and the backwater, I consider it would not be prudent to attempt it. It would manifestly be unwise to shut the Cruz Milagre Gap, for the purpose of improving Cochin, and at the same time to open another gap close by. In the long shallow coast at Narrakal, even though there is little surf, it would not be possible unless by incessant dredging to keep open the mouth of a canal, without a current through it of tidal water. It would not be safe, in the present absence of scientific data, to throw a current of water into the centre of the Narrakal mud-bank. So far as is known, that bank is stationary; but at Alleppey the bank there shifts, and has gone four miles to the south in ten years. The in-going stream also, during flood tide, would fill the backwater with mud. The banks are too valuable to try experiment with. The six feet line at no place here comes nearer shore than 900 yards in very soft mud, and in one place Captain Castor's chart shows it to be a mile from shore. Any canal, therefore, would require to be carried out between long protecting groynes, or it would be filled up almost every tide. I do not recommend the trial. A scouring current might be injurious to the mud-bank; and if a lock were put on the canal, the difficulty of keeping the entrance clear of mud would be great.

At Narrakal there already exists a small canal of 985 yards in length, from within 80 yards of the high water line to the Cochin backwater. This canal can be widened and deepened in connexion with any general improvement of the internal water communication, so as to admit large cargo boats, or even steamers. The canal is very close to the southern boundary of the smooth water at Narrakal, but it is at the point where the six feet line comes nearest to the shore. Boats landing goods

have to be dragged on shore for a long way through slush. A jetty would be an advantage, but it would require to be a very long one, three times as long as the pier at Calicut, to be of much use.

The three fathom anchorage is two and a quarter miles from shore.

Note by Mr. J. R. Bell on the Port of Cochin and the prospects of making the harbour accessible for sea going steam ships.

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27. *Hypothesis.*—I rather lean to Mr. Browning's ingenious view that certain rivers throw out submerged deltas in the sea and that these by dint of outside littoral currents, extend "Bills" which are inevitably followed by "Bights" running more or less parallel with the shore. The Bills perhaps tend in the long run to segregate new backwaters from the sea. Such theories unfortunately are of more academic interest than practical value. No one generation, or even century, is likely to see the whole process completed and I only mention this idea by way of explaining hypothetically the present situation immediately north of the Cochin entrance.

28. *The Vypeen divide.*—Whatever connexion exists between the discharge from the Periyar at Manambam, the original mud-flat anchorage off Narrakal and the gradual southward extension of that vast flat, it seems certain that the extension has cut off Narrakal from the sea and has moved down the anchorage to Malipuram. The flat constitutes, ex-hypothesi, a Bill and it is undoubtedly succeeded by a Bight which, at least ever since 1835, has continuously worn away the Vypeen seashore. We don't seem to have any express technical term to describe a comparatively narrow width of spit which segregates the sea from an adjacent backwater. For convenience I will here

call it the Vypeen divide. According to Mr. O'Shaughnessy's map, made in 1869, this divide has worn away from over a mile wide in 1835 to a bare 100 yards and is now mainly a mere super-bar. The 1835 shore line was presumably defined by Lieutenant Robertson, R. N., who recorded 15 to 17 feet of water (perhaps according to the tide rise) on Cochin bar.

** ** **

15th February 1913. JAS. R. BELL.

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